INEEL Oversight
Idaho's eyes on the INEEL

2001 Environmental Surveillance Report

A compilation and explanation of data collected by the INEEL Oversight Program during 2001

State of Idaho, INEEL Oversight Program

Environmental Sampling Coordinators
Air and External Radiation: Luke Paulus
Terrestrial: Luke Paulus
Water: L. Flint Hall
Water Verification: David Frederick

Quality Assurance/Quality Control Coordinator
Kristi Moser

Radiological Analysis Coordinator
Dr. Tom Gesell
Idaho State University

Nonradiological Analysis Coordinator
Barry Pharaoh
IDHW Bureau of Laboratories

Idaho Falls
900 N. Skyline Dr. Ste C
Idaho Falls, ID 83402
Ph. (208) 528-2600
Fax: (208) 528-2605

Boise
1410 N. Hilton
Boise, ID 83706
Ph. (208) 373-0498
Fax: (208) 373-0429

World Wide Web
http://www.oversight.state.id.us
Toll Free: 1-800-232-4635

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Abstract

After completing an independent assessment of the environmental conditions in the vicinity of the Idaho National Engineering and Environmental Laboratory (INEEL) during 2001, the State of Idaho's INEEL Oversight Program (INEEL OP) concluded:

- No offsite environmental impacts from INEEL operations were evident as a result of particulate air sampling.
- Tritium was measured in atmospheric moisture samples from one boundary monitoring location and three onsite-monitoring locations. However, these concentrations are significantly below risk-based threshold levels.
- No offsite environmental impacts from INEEL operations were evident in the milk or soil samples.
- At monitoring locations on and near the INEEL, gamma radiation measurements remained within background levels.
- Of the contaminants that the INEEL OP monitors in groundwater, only tritium and chromium were above background levels near the southern boundary of the INEEL. However, concentrations were less than the EPA drinking water standards.
- In some cases, the contaminants detected in groundwater on the INEEL did exceed EPA drinking water standards; however, these detections were not from wells used for drinking water.
- The wastewater and groundwater verification program for onsite locations shows that most of the INEEL OP data correlate well with data from the primary contractor, Argonne National Laboratory-West, and the Naval Reactors Facility.
- Analytical data reported by surveillance programs of the INEEL OP and the U.S. Department of Energy (DOE) generally agree.

The state of Idaho will continue monitoring conditions at and near the INEEL to assess potential impacts on public health and the environment.

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Introduction

To determine the impacts that INEEL activities may have on public health and the environment, the State of Idaho maintains the INEEL Oversight Program (INEEL OP). The INEEL OP provides independent assessments of contaminants resulting from DOE activities at the site. It monitors the condition of air, water, external radiation, and soil within the boundaries of the INEEL and air, water, external radiation, soil, and milk at offsite locations. The INEEL OP reports data from these environmental surveillance efforts quarterly and annually, and reviews data collected from previous years to identify any discernible trends. The INEEL OP's independent findings are used to compare with and supplement data reported by DOE surveillance programs.

Several organizations were responsible for carrying out the DOE's environmental surveillance program at the INEEL during 2001. Bechtel BWXT Idaho, LLC (BBWI) measured external gamma radiation and analyzed environmental samples of air, drinking water, and soil within the boundaries of the INEEL, and performed limited sampling offsite.

The S.M. Stoller Environmental Surveillance Education and Research Corporation (ESER) provided environmental surveillance outside the boundaries of the INEEL, and to a limited extent, within the boundaries. Environmental measurements made by ESER included external radiation, analysis of airborne particulate matter, water (drinking and surface), animal tissue, foodstuffs (milk, potatoes, wheat, and lettuce), and soil. Argonne National Laboratory-West (ANL-W) performed the monitoring at that facility, and Bechtel Bettis conducted monitoring at the Naval Reactors Facility (NRF). Groundwater surveillance was conducted primarily by the United States Geological Survey (USGS), which samples aquifer wells on the INEEL and throughout the Eastern Snake River Plain.

The INEEL OP does not attempt to duplicate the DOE's extensive surveillance network. Instead, select locations are sampled to provide a representative overview of the environment on and around the INEEL. Comparison with DOE's data is accomplished by analyzing samples of air, soil, milk, and water collected at the same place and approximate time. In those instances where the INEEL OP collects samples at different locations and/or with different instruments, or for different analyses, the subsequent results supplement data collected by the other organizations.

The following sections briefly describe the INEEL OP's environmental surveillance programs, summarize the 2001 surveillance results, discuss identified trends, and present comparisons of the data reported by the INEEL OP and various DOE monitoring programs.

Air and External Radiation Monitoring

Air Monitoring-Particulate Matter and Gaseous Radionuclides

Monitoring Network and Instrumentation

In 2001, the INEEL OP operated 10 air monitoring stations strategically located on and around the INEEL. Air monitoring data for samples collected at an air monitoring station in Fort Hall operated by the Shoshone-Bannock Tribes are also included for this report. At all 11 locations, intermediate flow PM_{10} samplers operate continuously collecting particulate matter with an aerodynamic diameter less than 10 micrometers. A charcoal cartridge designed to adsorb gaseous radioiodine is placed in series following the particulate filter within each PM_{10} sampler.

In mid-January of 2001, INEEL OP began investigating an alternative particulate air sampling method to potentially replace the existing PM_{10} samplers. High-volume total suspended particulate (TSP) samplers were deployed at the 10 air monitoring stations. The data collected by the two sampling methods during 2001 are being compared to determine whether or not the TSP samplers are an appropriate replacement to the PM_{10} samplers.

Sample Collection Methods and Analysis

Sample collection and analysis followed regular schedules and written sampling and analysis plans as well as procedures. On a weekly basis, INEEL OP staff collected the filters and charcoal cartridges from the PM_{10} and TSP samplers. Filters were analyzed with gas-flow proportional counting to measure gross alpha and gross beta radioactivity. Charcoal cartridges were analyzed with gamma spectroscopy to detect gamma-emitting radionuclides, with specific reporting of iodine-131. On a quarterly basis, the filters were composited by location and analyzed with gamma spectroscopy for man-made, gamma-emitting radionuclides, with specific reporting of ruthenium/rhodium-106, antimony-125, cesium-134, and cesium-137. PM_{10} samples from all four quarters of 2001 were then composited by location and analyzed for strontium-90, plutonium-238, plutonium-239/240, and americium-241.

Results, Trends, and Interprogram Comparisons

Air monitoring results for 2001 are summarized below, as are any trends identified through the evaluation of air monitoring data collected by the INEEL OP since 1994. In addition, these results are compared to those reported by BBWI and DOE's offsite contractor at four air monitoring stations that are co-located with those operated by INEEL OP.

Gross Alpha and Gross Beta Radioactivity

Particulate air samples collected during 2001 showed concentrations of airborne radioactivity at typical historical background values. Elevated gross alpha concentrations observed at onsite, boundary, and distant monitoring locations are likely due to elevated concentrations of radon progeny. Elevated concentrations of gross beta activity were observed at all of the monitoring sites during the first week of January and during the last weeks of December. At all onsite, boundary, and distant locations, the 2001 atmospheric concentrations of gross beta are most likely due to naturally occurring radon progeny. The elevated gross alpha and beta measurements at the end of the year were likely due to a temperature inversion that held radon progeny in the lower portion of the atmosphere. These conclusions are supported by gamma spectroscopy and radiochemical analyses results discussed below.

Trend analysis of gross alpha and gross beta radioactivity data collected by the INEEL OP since 1994 shows that both measurements fluctuate following natural seasonal patterns at each of the sample sites.

Direct comparisons between PM_{10} sampling data and TSP sampling data show relatively good agreement.

Direct comparisons of gross alpha and beta screening measurements with other programs were difficult to quantify due to variations in air-sampling methodologies between these programs. However no serious disagreements were noted.

Radioiodine

No iodine-131 was detected on charcoal cartridges collected in 2001, and none has been detected since the INEEL OP began air sampling in 1994. Similarly, the DOE monitoring programs did not report any iodine-131 during the 2001 sampling period.

Gamma Spectroscopy Results

Gamma spectroscopy performed on the 2001 quarterly composited particulate filters did not detect the presence of man-made, gamma-emitting radionuclides above minimum detectable concentrations (MDC).

Beryllium-7, a naturally occurring cosmogenic radionuclide, was reported exceeding the detection capability of the laboratory. The levels of beryllium-7 concentrations were consistent for each sampling period at onsite, boundary, and distant locations.

Radiochemical Results

Plutonium-239/240 was reported by a sub-contractor laboratory for the PM_{10} composite collected at Craters of the Moon National Monument. This value was rejected since plutonium-239/240 was not measured on the TSP composite collected at the same location during the same sampling period. No other transuranic radionuclides were detected on annual filter composites.

Strontium-90 was measured at several monitoring locations, but the concentrations observed were well below levels that would pose a risk to human health

Air Monitoring - Atmospheric Moisture and Precipitation

Monitoring Network and Instrumentation

In 2001, the INEEL OP operated 10 atmospheric moisture sampling stations strategically located on and around the INEEL. Atmospheric moisture data collected at Ft. Hall are also included in this report. At all 11 locations, air samplers containing cartridges filled with molecular sieve beads were co-located with the PM_{10} air monitoring stations. The beads adsorb and retain moisture from air drawn through the cartridges by a pump.

Additionally, six of the eleven atmospheric moisture sampling stations are equipped with vessels to collect precipitation.

Sample Collection Methods and Analysis

The molecular sieve beads were collected at the end of each quarter, or when the beads had almost reached saturation, whichever occurred first. Moisture removed from the beads was analyzed for tritium, a radioactive isotope of hydrogen. Precipitation was collected quarterly or sooner if the container became full, and was analyzed for tritium and gamma-emitting radionuclides.

Results, Trends, and Interprogram Comparisons

Tritium

Tritium was detected in atmospheric moisture samples at two onsite monitoring locations, the Experimental Field Station and Van Buren. The tritium concentrations observed onsite are significantly below levels that would pose a risk to human health. Each program follows slightly different protocols for monitoring extremely low concentrations of tritium in the atmosphere. Different adsorbents, different sampling periods, and other

interprogram variables complicate direct comparisons between programs. Differences between INEEL OP and BBWI atmospheric concentrations are likely due to different, but equally valid, analytical techniques and sampling schedules. Variations between INEEL OP and ESER atmospheric concentrations are due to differences in adsorbent media, analytical techniques, and sampling schedules used by individual monitoring programs. While there are differences in results, they are not significant in view of the minute concentrations reported by all three monitoring groups. No tritium was observed in INEEL OP precipitation samples collected in 2001.

Gamma Spectroscopy Results

Precipitation samples collected during 2001 did not show measurable concentrations of man-made, gamma-emitting radionuclides, as has been the case since 1994, when the INEEL OP began collecting precipitation. INEEL OP and ESER have only one co-located site for precipitation, and neither program detected any measurable concentrations of man-made, gamma-emitting radionuclides at that site.

External Radiation Monitoring

Monitoring Network and Instrumentation

In 2001, the INEEL OP maintained a network of 10 stations equipped with high-pressure ion chambers (HPICs), which continuously measure environmental penetrating radiation levels from natural cosmic and terrestrial sources, as well as from operations at the INEEL. Environmental radiation data collected at Fort Hall were also reported. At each of the radiation monitoring stations, Electret Ion Chambers (EICs) were deployed to provide a cumulative total of radiation exposure for the calendar quarter.

Measurement and Analysis

Penetrating radiation levels measured by the HPICs were compiled to provide daily, weekly, monthly, and quarterly average exposure rates. EICs were collected and analyzed quarterly.

Results, Trends, and Interprogram Comparisons

Penetrating radiation measurements from the HPICs were consistent with historic background levels measured by the INEEL OP. Because these instruments are not co-located with DOE's, a comparison could not be made.

Penetrating radiation readings for the EICs were also consistent with historical background results. Although the results reported by the INEEL OP, BBWI, and ESER in 2001 fell within levels accepted as background, direct comparisons of the programs' results reflect interprogram variation due to different measurement schedules and monitoring techniques. Also, EICs used by INEEL OP are slightly more responsive to low-energy gamma and x-ray photons than the instruments used by other organizations and show slightly higher exposures.

Terrestrial Monitoring

Monitoring Network and Instrumentation

Milk was collected monthly at five processing plants in southeastern Idaho and the Magic Valley. These plants processed milk from dairies located both near and distant from the INEEL boundary.

Soil samples were collected from 17 locations on the INEEL as well as at boundary and distant locations.

Sample Collection Methods and Analysis

Milk samples were collected from fresh dairy shipments and analyzed using standard gamma spectroscopic methods. Iodine-131 and naturally occurring potassium-40 results are always reported, while other gamma-emitters are reported only if they exceed detection limits.

Traditionally, soil samples were collected from undisturbed locations near radiation monitoring stations at two depths, 0-5 cm and 5-10 cm, and analyzed with gamma spectroscopy. Rather than disturb the soil and physically collecting a sample, the concentrations of radionuclides in soil were measured *in-situ* (i.e., directly in the field). Radionuclide concentrations are determined using an intrinsic, high purity germanium detector assuming the distribution of radionuclides in the soil was homogenous throughout a soil depth of 0 to 5 cm.

Results, Trends, and Interprogram Comparisons

Naturally occurring potassium-40 was the only radionuclide detected in milk samples. Levels were consistent with concentrations measured by the INEEL OP in the past. The reported concentrations of iodine-131 have been less than the minimum detectable concentration since the inception of milk sampling in 1996. Likewise the ESER milk monitoring program did not detect iodine-131 over this same period.

INEEL OP conducted seven *in-situ* measurements with BBWI in 2001 for comparison purposes. Some differences were expected between gamma spectroscopic results due to analytical differences, but the cesium-137 concentrations reported by BBWI and INEEL OP correlated relatively well. During 2001, the INEEL OP did not co-sample soil with ESER.

Water Monitoring

Monitoring Network and Instrumentation

The INEEL OP monitors water quality at 88 locations: 26 groundwater and surface water sites on and around the INEEL, 5 drinking water sites and springs distant from the INEEL, and 55 groundwater and springs in the Magic Valley. The 28 INEEL sites, 5 distant sites, and 18 Magic Valley sites are sampled each year. INEEL OP also co-samples with the DOE's primary contractor, the monitoring group at ANL-W, and NRF at 11 wastewater locations and 18 groundwater locations on the INEEL.

Sample Collection Methods and Analysis

Water samples are collected and analyzed not only to detect contaminants known to have been disposed at INEEL facilities, but also to compare with and supplement INEEL data and provide information on general water quality.

Results, Trends, and Interprogram Comparisons

Nonradiological Constituents

Calcium, chloride, magnesium, potassium, sodium, sulfate, total nitrogen and total phosphorus are known INEEL waste constituents that were detected above background levels in 2001 at some wells within known contamination plumes on the INEEL. However, none of the samples collected by the INEEL OP since 1994 exceeded the drinking water standards for these constituents.

Trace metals, barium, chromium, lead, manganese, and zinc were detected above background levels in samples collected within known groundwater contaminant plumes on the INEEL. Only chromium exceeded the maximum contaminant level (MCL) for drinking water, and only at one well that is not used for drinking water. Barium was detected above background at wells near the Idaho Nuclear Technology and Engineering Center (INTEC) and the Central Facilities Area (CFA). Chromium was above background levels in several wells on the INEEL due to historic wastewater disposal at the Test Reactor Area (TRA) and INTEC. Elevated levels of lead, manganese, and zinc may be attributable to well construction materials, existing natural concentrations in the environment, and INEEL activities. These findings are consistent with results reported by INEEL OP since 1994. During 2001, replicate samples for nonradiological constituent analysis were collected with the USGS at 26 groundwater and surface water locations on and near the INEEL, and at 18 locations in the Magic Valley. The INEEL OP and ESER co-sampled at three springs and two drinking water supply wells south of the INEEL and in the Magic Valley. INEEL OP and ESER sampled two additional locations, although not at the same date and time. Comparisons of nonradiological data reported by the INEEL OP and the USGS show excellent agreement for all replicate data.

The nonradiological results reported by the INEEL OP for the verification monitoring program were generally similar to the results reported by ANL-W, NRF, and the DOE's primary contractor at the INEEL. Replicate sample pairs for barium, chloride, copper, nitrate + nitrite, sulfate, TKN, iron, ammonia, total dissolved solids, and total suspended solids failed the comparison criteria. Differences in results were generally attributed to sample heterogeneity; differences in analytical methods; or in some cases, the failure to consider sample interference by the analysis laboratory.

Radiological Constituents

Gross alpha screening measurements exceeded detection limits for samples collected at 12 locations during 2001. Gross alpha radioactivity measurements were well below the MCL and within expected background levels.

Concentrations of gross beta radioactivity were detected above background in samples from onsite wells. The highest concentrations were observed for two wells known to be impacted by INEEL wastewater. Radiochemical analyses of selected samples from these onsite wells indicate that strontium-90 is the primary source of the gross beta radioactivity. Although strontium-90 exceeded the drinking water standard at one of these wells, the well is not used for drinking water.

Analyses were also conducted for gamma emitters and technetium-99. No gamma emitters were detected except for naturally occurring potassium-40 at six sites. Technetium-99, a fission product created in nuclear reactors, was detected in samples collected from four of the five wells sampled on the INEEL.

Concentrations of tritium caused by historical waste-disposal practices were detected at levels near, but below, the drinking water standard at several INEEL wells. Overall, tritium concentrations appear to be decreasing within the identified plume. Elevated levels of tritium measured in wells at the Radioactive Waste Management Complex (RWMC) have remained fairly constant since INEEL OP began sampling. At offsite wells near the southern INEEL boundary, tritium has been detected at levels above background, but those levels are only about one percent of the drinking water standard.

The INEEL OP collected replicate samples in 2001 with the U.S. Geological Survey (USGS) on and near the INEEL, and south of the INEEL to the Snake River Canyon between Twin Falls and Hagerman. Replicate samples were also available for the five locations where the INEEL OP co-samples with ESER in Magic Valley. In addition, data for two additional locations where both INEEL OP and ESER collect samples were included in the comparisons. In general, the INEEL OP's radiological sample results showed good agreement with data reported by co-sampling organizations. Excellent agreement was noted for all nonradiological parameters. Although statistically significant differences were observed for gross alpha and gross beta radioactivity, these differences were relatively small compared to the concentrations observed. Data from co-sampled locations showing the greatest relative differences were strongly influenced by differences in analytical methods and sampling practices.

For the verification program, gross beta results were the only radioactivity analyses that did not meet the comparison criteria. The differences in the gross alpha analyses are attributed to normal analytical variability or sample heterogeneity. INEEL OP gross beta results are consistently lower than the contractor data. The cause for this bias is under investigation by INEEL OP.

Chapter 1
Introduction

Oversight Program Mission and Environmental Surveillance Program

The mission of the state of Idaho's Idaho National Engineering and Environmental Laboratory Oversight Program (INEEL OP) is to provide the people of Idaho with independent, factual information about the INEEL, to help ensure the safety of the citizens of Idaho through the protection of public health and the environment, and to provide statewide radiological expertise. In partial fulfillment of this mission, the INEEL OP developed an Environmental Surveillance Program (ESP) with the following objectives:

- Maintain an independent environmental surveillance program designed to verify and supplement U.S. Department of Energy (DOE) surveillance programs.
- Provide the citizens of Idaho with information that has been independently evaluated to enable them to reach informed conclusions regarding the potential impacts of present and future DOE activities in Idaho.

This report documents the 2001 findings, developments, and conclusions of the INEEL OP ESP.

This annual report is intended to address the question: What is the impact of the INEEL on public health and the environment? The information provided herein represents the surveillance data resulting from environmental measurements made by the state of Idaho's INEEL OP on and around the INEEL during 2001.

The purpose of the INEEL OP ESP is to verify and selectively supplement surveillance information gathered by other surveillance programs, including the U.S. Geological Survey (USGS) and DOE-associated programs conducted by Bechtel BWXT Idaho, LLC (BBWI), Argonne National Laboratory-West (ANL-W), Bechtel-Bettis Naval Reactors Facility (NRF), and the S.M. Stoller Environmental Surveillance Education and Research (ESER) Corporation.

Each of these organizations performs monitoring tasks of defined scope; collectively, these programs gather data on a broad variety of media. To substantiate and augment the results

reported by these surveillance programs, the INEEL OP measures external gamma radiation and samples air, precipitation, surface water, groundwater, wastewater, soil, and milk at a number of strategically selected sites. The INEEL OP maintains monitoring locations separate from the other organizations to compile independent measurement results, conduct autonomous evaluations of results, and analyze data trends. Also, the INEEL OP collects environmental samples throughout the year at many of the same sites and when possible, at the same time as the other surveillance programs. The independence of both the primary and comparative results is preserved by the INEEL OP's contracting the analytical services of two laboratories not associated with any of DOE's surveillance programs: the Idaho State University Environmental Monitoring Laboratory (ISU EML) in Pocatello, and the State of Idaho Department of Health and Welfare Bureau of Laboratories in Boise (IBL).

The INEEL OP's annual findings, developments, and conclusions are presented in the following sections:

Environmental Surveillance Program Scope and Affiliations:

Section includes descriptive outline of the full scope of the INEEL OP's ESP, including monitoring locations, instrumentation, methodologies and interprogram relationships between the INEEL OP, DOE, and other organizations.

Air, Gamma Radiation, Terrestrial, and Water Monitoring Results:

Section includes individual chapters containing the 2001 data for each media of the INEEL OP network; discussions of identifiable trends; comparisons of 2001 data to previously collected data; and comparisons of INEEL OP results to those reported by DOE and other surveillance programs.

Environmental Surveillance Program's Quality Assurance and Quality Control (QA/QC) Results:

Section includes summary of QA/QC activities for the year including any corrective actions identified and taken.

Conclusion:

A summation of the program's critical findings.

Appendices:

Addenda on specific topics addressed in the preceding sections:

Appendix A--initial development and design of the INEEL OP ESP.
Appendix B--glossary of technical terms and units used in this report.

Analytical results are available in either electronic or printed format. They can be downloaded from the INEEL Oversight Program's website at: http://www.oversight.state.id.us, or requested by contacting 1-800-232-4635, or:

State of Idaho,
INEEL Oversight Program
900 N. Skyline, Suite C
Idaho Falls, ID 83402

Chapter 2
Environmental Surveillance Program Scope and Affiliations

INEEL Oversight Program Environmental Surveillance Program History and Legislative Authority

The INEEL OP was created when there was growing concern about environmental contamination from activities at DOE facilities. In the late 1980s, the U.S. Secretary of Energy proposed an oversight role for states hosting these DOE facilities. According to this proposal, states would receive funding and information that would enable them to independently assess environmental conditions and activities at DOE facilities. In 1989, the Idaho Legislature enacted Senate Bill 1266, establishing a comprehensive oversight program for the INEEL. In May 1990, the state and DOE signed a five-year Environmental Oversight and Monitoring Agreement. This agreement, which has subsequently been renewed for two additional, five-year periods, funded the state's INEEL OP and set forth the following responsibilities:

- Secure independent data and information regarding DOE activities in Idaho;
- Scientifically evaluate information on INEEL impacts to the public and environment; and
- Independently report conclusions to the people of Idaho.

The INEEL Oversight Program (INEEL OP)

The INEEL OP's environmental surveillance network on and around the INEEL generates data that can be used to verify and supplement the results reported by Bechtel Bettis, BBWI, ANL-W, and ESER, as well as results published by the USGS.

The scope of the INEEL OP's network has expanded as goals and objectives for the program have evolved, as described in the history of the network's design and development provided in **Appendix A**.

Currently, the INEEL OP monitors multiple environmental media which have been or potentially could be contaminated by activities at the INEEL, including air, external gamma radiation, soil, milk, surface water, and groundwater.

Independent sampling is performed at selected, strategic locations. As summarized in **Table 2-1**, samples collected from these locations are routinely analyzed for a variety of constituents, and the analytical results compiled from this data form an independent base of scientific findings that can be used to verify results reported by DOE and other surveillance programs. Sampling frequency for some water monitoring sites was reduced beginning October 2001 in response to a reduction of sampling frequency by the USGS. This reduction is not reflected in **Table 2-1**.

To maintain the independent status of INEEL OP results, the INEEL OP contracts analytical services from two laboratories which are not associated with any of DOE's surveillance programs: the Idaho State University Environmental Monitoring Laboratory (ISU EML) in Pocatello, and the Idaho Bureau of Laboratories in Boise (IBL).

The ISU EML is the primary provider of radiological analytical services to the INEEL OP. Located in the Physics Department of the university, the laboratory performs analyses that include screening for gross alpha and gross beta radioactivity, gamma spectroscopy, liquid scintillation counting for tritium, and analysis for technetium-99 using Empore Selective Ion filter disks. Environmental samples requiring radiochemical analyses or other specific analyses are contracted out to other laboratories by the ISU EML. The ISU EML is also involved in other aspects of the INEEL OP ESP, including conducting applied research, providing technical guidance, assisting with program design, and providing student interns who participate in field sampling and data analysis.

The IBL is the primary provider for the non-radiological analyses of INEEL OP surface water and groundwater samples. For these samples, the laboratory supplies results on a suite of nonradiological analytes, including common ions, trace metals, nutrients, and volatile organic compounds (VOCs).

Each laboratory maintains an internal quality control program to ensure consistency and accuracy, and to provide a means of assessing the quality of the data reported. Should a laboratory note a concern that could potentially affect the quality of the data, the INEEL OP may assign a data qualifier to the analytical results for a particular sample, depending on the severity of the problem. During data validation by the INEEL OP, an analytical result may be rejected or accepted as an estimate, in accordance with protocols developed by the EPA.

Table 2-1. INEEL OP Environmental Surveillance Program (ESP) summary, 2001

Media Sampled Type of Analysis	Locations and Frequency[a]			Minimum Detectable Quantities
	Onsite	Boundary	Offsite	
Air				
PM_{10} Samplers				
Alpha	4 W	4 W	2 W	0.001 pCi/m^3
Beta	4 W	4 W	2 W	0.001 pCi/m^3
Gamma	4 Q[b]	4 Q[b]	2 Q[b]	0.003 pCi/m^3 (Cs-137)
Radiochemical[c]	4 A[b]	4 A[b]	2 A[b]	Varies
TSP Samplers				
Alpha	4W	4W	2W	0.001 pCi/m^3
Beta	4W	4W	2W	0.001 pCi/m^3
Gamma	4Q[b]	4Q[b]	2Q[b]	0.002 pCi/m^3 (Cs-137)
Radiochemical[c]	4 A[b]	4 A[b]	2 A[b]	Varies
Charcoal Cartridges				
Iodine-131	4 W	4 W	2 W	0.006 pCi/m^3
Atmospheric Moisture				
Tritium	4 Q	4 Q	3 Q	1 pCi/m^3
Precipitation				
Tritium	1 Q	4 Q	1 Q	160 pCi/L
Gamma	1 Q	4 Q	1 Q	6 pCi/L (Cs-137)
Gamma Radiation				
High-Pressurized Ion Chambers (HPIC)				
Gamma (µR/hr) (continuous readings)	5	5	1	1.4 µR/hr
Environmental Dosimeters (EIC)[g]	7Q	4Q	3Q	10 mR (estimated from typical 2 sigma)

Table 2-1 continued. INEEL OP Environmental Surveillance Program (ESP) summary, 2001

Media Sampled Type of Analysis	Locations and Frequency[a]			Minimum Detectable Quantities
	Onsite	Boundary	Offsite	
Terrestrial: Milk				
Gamma Spectroscopy				
Iodine-131			6 M	4 pCi/L (I-131)
Terrestrial: Soil				
Gamma Spectroscopy[d]	13 A	4 A	1 A	0.01 pCi/g (Cs-137)
Water: Radiological				
Alpha	33 Q/S[e]	13 Q/S[e,f]	5 Q, 18 of 55 T	2-5 pCi/L
Beta	33 Q/S[e]	13 Q/S[e,f]	5 Q, 18 of 55 T	2-3 pCi/L
Gamma	33 Q/S[e]	13 Q/S[e,f]	5 Q, 18 of 55 T	6-10 pCi/L (Cs-137)
Tritium	23 Q/S[e]	13 Q/S[e,f]	5 Q, 18 of 55 T	160 pCi/L (15-20 pCi/L for electrolytically enriched)
Sr-90	11 S[e]			3-4 pCi/L
Tc-99	4 S[e]			4-5 pCi/L
Water: Non-radiological				
Common Ions				
Total Alkalinity	15 Q/S[e] 23 A	13 Q/S[e,f]	5 A	1.0 mg/L
Calcium	15 Q/S[e] 23 A	13 Q/S[e,f]	5 A	0.1 mg/L
Chloride	15 Q/S[e] 23 A	13 Q/S[e,f]	5 A	2.0 mg/L
Fluoride	15 Q/S[e] 23 A	13 Q/S[e,f]	5 A	0.1 mg/L
Magnesium	15 Q/S[e] 23 A	13 Q/S[e,f]	5 A	0.05 mg/L
Potassium	15 Q/S[e] 23 A	13 Q/S[e,f]	5 A	0.1 mg/L
Sodium	15 Q/S[e] 23 A	13 Q/S[e,f]	5 A	0.1 mg/L
Sulfate	15 Q/S[e] 23 A	13 Q/S[e,f]	5 A	2-4.5 mg/L
Nutrients				
Nitrate + Nitrite as Nitrogen	15 Q/S[e] 23 A	13 Q/S[e,f]	5 A	0.005 mg/L
Nitrogen (ammonia)	23 A			0.005 mg/L
Nitrogen (Kjeldahl)	23 A			0.05 mg/L
Phosphorus	15 Q/S[e] 23 A	13 Q/S[e,f]	5 A	0.05 mg/L
Trace Metals				
Aluminum	23 A			50 μg/L

Table 2-1 continued. INEEL OP Environmental Surveillance Program (ESP) summary, 2001

Media Sampled Type of Analysis	Locations and Frequency[a]			Minimum Detectable Quantities
	Onsite	Boundary	Offsite	
Antimony	23 A			5 μg/L
Arsenic	23 A			10 μg/L
Barium	15 Q/S[e] 23 A	13 Q/S[e,f]	5 A	1 μg/L
Beryllium	23 A			1 μg/L
Cadmium	23 A			100 μg/L
Chromium	15 Q/S[e] 23 A	13 Q/S[e,f]	5 A	2 μg/L
Cobalt	23 A			5 μg/L
Copper	23 A			10 μg/L
Iron	23 A			10-20 μg/L
Lead	15 Q/S[e] 23 A	13 Q/S[e,f]	5 A	5 μg/L
Manganese	15 Q/S[e] 23 A	13 Q/S[e,f]	5 A	10 μg/L
Mercury	23 A			0.5 μg/L
Nickel	23 A			10 μg/L
Selenium	23 A			5 μg/L
Silver	23 A			1 μg/L
Thallium	23 A			1.5 μg/L
Vanadium	23 A			10 μg/L
Zinc	15 Q/S[e] 23 A	13 Q/S[e,f]	5 A	5 μg/L
Volatile Organic Compounds	5 A			0.5 μg/L

a. Sample frequency: W – weekly, M – monthly, Q – quarterly, S – semiannually, A – annually, T–triennially
b Quarterly and annual analyses performed on composited weekly samples for each location.
c. Radiochemical analyses include Pu-238, Pu-239/240, Am- 241, and Sr-90.
d. Gamma spectroscopy of soil samples includes examination of the spectra specifically for the man-made gamma-emitters Cs-137 and Co-60 and the naturally occurring gamma-emitters Bi-214, Pb-214, and Ac-228. Other radionuclides occurring above the detection limit will be identified by the analysis software.
e. Quarterly and semi-annual sampling schedules with varied frequencies.
f. Includes three surface water sites.

Other Surveillance Programs

Bechtel BWXT Idaho, LLC (BBWI)

As the INEEL operating contractor for the DOE, BBWI is responsible for collecting and analyzing radiological and nonradiological samples for the Site Environmental Surveillance Program. BBWI conducts onsite monitoring of air, water, soil, and vegetation, with some limited offsite sampling for comparative purposes. BBWI contracts with an outside laboratory.

The S.M. Stoller Corporation (ESER)

In November 2000, DOE awarded the offsite monitoring under their Environmental Surveillance Education and Research contract to the S. M. Stoller Corporation (ESER). ESER also performs some limited onsite monitoring. Currently, ESER results applicable to interagency comparisons include those for samples collected from the air and external radiation measurements, and

samples of ground and surface water, soil, and milk. In an effort to maintain independence, ESER employs the services of the ISU Environmental Assessment Laboratory (ISU EAL), which remains separate from the ISU EML, for radiological analyses, and contracts with an outside laboratory for radiochemical analyses.

United States Geological Survey (USGS)

As part of the long-term collection of hydrological and geological data related to the presence and movement of radioactive and nonradioactive constituents in groundwater, the USGS conducts ground and surface water monitoring both on and off the INEEL. Samples collected by the USGS on and near the INEEL are analyzed by the DOE Radiological and Environmental Sciences Laboratory (RESL), and by the USGS National Water Quality Laboratory in Arvada, Colorado. Analytical results are presented in USGS reports.

Argonne National Laboratory (ANL-W)

The University of Chicago operates Argonne National Laboratory, with facilities in Illinois (ANL-E) and Idaho (ANL-W), for DOE. As a separate organization from BBWI, ANL-W operates its own environmental sampling program, and contracts with outside laboratories for analyses.

Naval Reactors Facility

Naval Reactors Facility (NRF) is operated for the Naval Nuclear Propulsion Program, United States Department of Energy, Naval Reactors, by Bechtel Bettis, Inc. As a separate organization from BBWI, NRF operates its own environmental sampling program, and contracts with an outside laboratory for analyses.

Shoshone-Bannock Tribes

The Shoshone-Bannock Tribes operate a community air monitoring station at Fort Hall similar in design and complement of instruments to the INEEL OP community monitoring stations. These samples are also analyzed by the ISU EML.

The INEEL OP Sampling Network and Co-Sampling Strategies

Air Monitoring

Air samples collected by the INEEL OP in 2001 were screened for gross alpha and gross beta radioactivity, and gamma radioactivity, and analyzed for tritium in atmospheric moisture. Radiochemical analyses were performed on composited air filters for strontium-90, plutonium-238 and -239/240, and americium-241. Typically, the INEEL OP reports all results

for gross alpha and beta radioactivity, but notes only those gamma spectroscopy results exceeding the minimum detectable concentration (MDC). As part of gamma spectroscopic analyses, specific results are reported by the laboratory for ruthenium/ rhodium-106, antimony-125, cesium-134, and cesium-137.

Air Monitoring Locations

Extensive studies of the complex wind patterns of the Eastern Snake River Plain strongly influenced the placement of the stations in the original INEEL OP air monitoring network. From an initial six monitoring sites in 1992, the ESP has expanded to include the ten air monitoring stations identified in **Figure 2-1**. Currently, each of these stations is equipped with instruments to collect airborne particulate matter, gaseous radioiodine, and water vapor. Six stations are equipped to collect precipitation. The INEEL OP also reports air monitoring data for samples collected at a station in Fort Hall operated by the Shoshone-Bannock Tribes.

Each monitoring station is categorized by location as onsite, boundary, or distant. **Table 2-2** lists the sample types, frequency, and analyses conducted by the INEEL OP for each location, and also identifies the comparable schedule and analysis activities for other agencies sampling at each location.

Air Monitoring Equipment and Procedures

Air Samplers

Intermediate-flow PM_{10} samplers operate continuously at each of the air monitoring stations to collect particulate matter measuring less than ten micrometers in aerodynamic diameter. In mid-January, an investigation for a suitable replacement for aging PM_{10} samplers began when high-volume total suspended particulate (TSP) samplers were deployed at each of the air monitoring stations. Samples are collected on 4-inch Versapore membrane filters. Filters are collected weekly and stored for approximately five days in a desiccator to allow for the radioactive decay of short-lived radon progeny prior to gross alpha and gross beta radioactivity screening analyses. PM_{10} and TSP filter samples are analyzed for gross alpha and gross beta radioactivity.

To collect gaseous radioiodines, primarily iodine-131, an activated charcoal sorbent cartridge is placed directly in line behind the particulate air filter in each PM_{10} sampler. The charcoal cartridges are collected weekly and analyzed for gamma-emitting radionuclides.

During 2001, the particulate filters and charcoal cartridges were collected and analyzed according to the schedules outlined in **Table 2-2**. Following weekly individual analyses for gross alpha and beta radioactivity, filters were composited by location for quarterly analyses of specific radionuclides by gamma spectroscopy.

To obtain additional data for the evaluation of trends in air quality, the INEEL OP has introduced annual radiochemical analyses of the particulate air filters. From 1996 to the present, the particulate filters have been composited annually by location and sent to a commercial laboratory for radiochemical analyses of strontium-90, plutonium-238, plutonium 239/240, and americium-241.

Precipitation Samplers

Six of the INEEL OP air monitoring stations are equipped to collect precipitation samples for radiological analyses, as shown in **Table 2-2.** The precipitation is collected on a one-meter square, metal tray attached to a polyethylene collection vessel. At the end of each quarter or when the collection vessel is nearly full, whichever occurs first, the precipitation samples are collected, composited by quarter if necessary, and analyzed for tritium and gamma-emitting radionuclides.

Atmospheric Moisture Samplers

Atmospheric moisture is collected at eleven of the monitoring stations by passing air through a column containing a mixture of molecular sieve beads, which are capable of removing and storing moisture from the air. As indicated in **Table 2-2**, the samples are collected when the beads nearly reach saturation or at the end of each quarter, whichever occurs first. Heating the beads releases the moisture, which is then collected as condensation and analyzed for tritium.

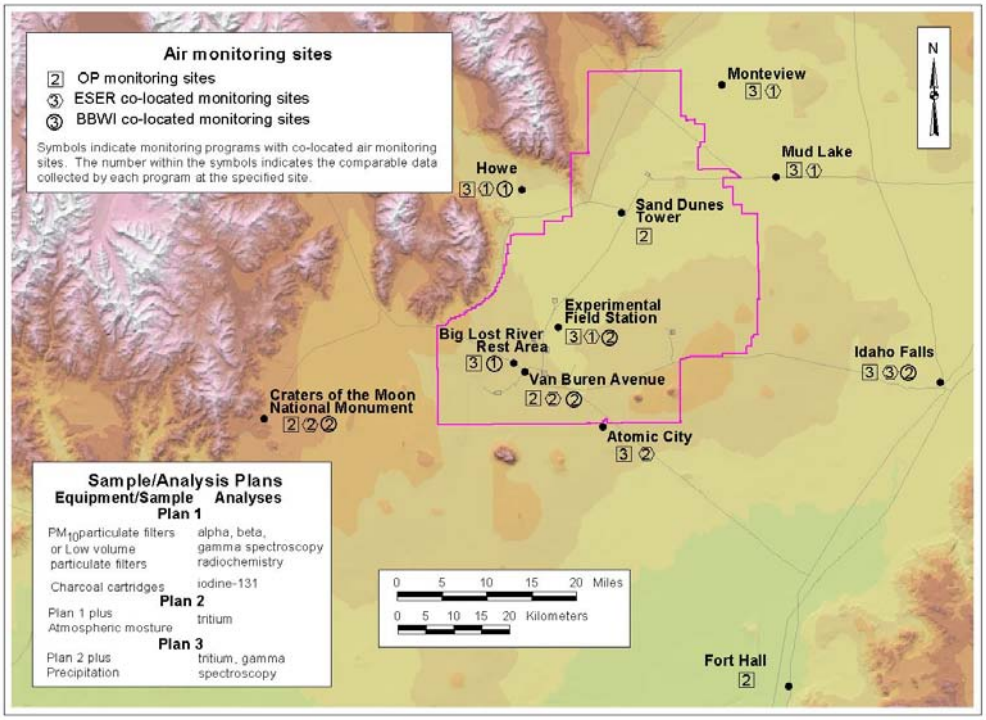


Figure 2-1. Air Monitoring Locations.

Air Monitoring Quality Assurance/ Quality Control

Quality control for the air monitoring program is maintained through adherence to the INEEL OP standard operating procedures. The INEEL OP routinely conducts quality control checks for all field air sampling measurements and laboratory analyses. Air flow rates and volume measurements for particulate samplers and atmospheric moisture samplers receive annual performance evaluations. Air sample results are reviewed for adequate sample volume before final results are calculated.

Quality control checks also involve the preparation of external field blanks and internal laboratory protocols. Field blanks are prepared weekly for the air particulate filters and quarterly for atmospheric moisture samples. The laboratory's internal protocols include instrument performance checks, sample recounts, and cross-check programs.

Interprogram Air Sampling Results and Comparisons

As indicated in **Figure 2-1**, the INEEL OP, BBWI, and ESER conducted co-located sampling activities throughout 2001, with each organization separately performing the range of scheduled analyses identified. In this report, the results of INEEL OP measurements are compared directly to those of the two DOE monitoring programs.

Each organization performing air sampling as part of its respective surveillance program collects airborne particulate matter, but collection equipment varies slightly. The INEEL OP uses intermediate flow PM_{10} and high-volume TSP samplers; ESER and BBWI use low-volume particulate air samplers.

Each agency performing air sampling conducts gross alpha and gross beta radioactivity screening analyses, gamma spectroscopic analyses of composite filter samples, and radiochemical analyses of composite filter samples, although radiochemical analyses are done on different schedules on samples from different locations by the various organizations. Each group collects iodine-131 samples using activated charcoal cartridges that are analyzed by gamma spectroscopy.

The sampling schedules, analyses, and instruments used by the participating agencies are listed in **Table 2-2**. The INEEL OP and BBWI each collected particulate, radioiodine, and composite atmospheric moisture samples at four identical or nearby locations. The INEEL OP and ESER collected particulate, radioiodine, and composite atmospheric moisture samples at four identical or nearby locations.

Linear regressions, Quantile-Quantile plots, and paired t-tests were the primary statistical tools used to compare the gross alpha, gross beta, and gamma spectroscopy results from these locations. Comparison results are presented in **Chapter 3**.

Table 2-2. Interprogram air monitoring sampling/analyses schedules, 2001

Co-located Sampling Instrumentation, Scheduling, and Analyses				
Equipment/Sample Types	**Particulate Air Sampling**	**Charcoal Cartridges**	**Atmospheric Moisture**	**Precipitation**
Frequency of Sampling	**Weekly**	**Weekly**	**Quarterly[e]**	**Quarterly[f]**
Analyses[a, b]	**Alpha, Beta, Gamma Radiochemistry[d]**	**Iodine-131[c]**	**Tritium**	**Tritium, Gamma**
Onsite Locations/Organization*				
Experimental Field Station	OP ESER BB	OP ESER BB	OP ESER BB	ESER
Sand Dunes	OP	OP	OP	
Van Buren Avenue	OP ESER BB	OP ESER BB	OP BB	
Big Lost River Rest Area	OP	OP	OP	OP
Boundary Locations/Organization*				
Atomic City	OP ESER	OP ESER	OP ESER	OP
Howe	OP ESER BB	OP ESER BB	OP	OP
Monteview	OP ESER	OP ESER	OP	OP
Mud Lake	OP ESER BB	OP ESER BB	OP	OP
Distant Locations/Organization*				
Idaho Falls	OP ESER BB	OP ESER BB	OP ESER	OP ESER
Craters of the Moon	OP ESER BB	OP ESER BB	OP BB	
Fort Hall	SB	SB	OP	

*Sampling Organization Abbreviations:
OP = INEEL OP ESER = Stoller BB = BBWI SB = Shoshone-Bannock Tribes

a. The INEEL OP samples the PM_{10} fraction of airborne particulate matter; ESER and BBWI sample total particulate matter.
b. Identifies all INEEL OP analyses and those co-sampling agency analyses used for comparisons of results.
c. Samples composited by location and analyzed by gamma spectroscopy on different schedules.
d Samples composited by location and analyzed by radiochemical techniques for Pu-238, Pu-239/240, Am-241, and Sr-90 on different schedules.
e Samples are collected quarterly or when beads reach saturation.
f Samples are collected quarterly or when sample container is full, whichever occurs first.

Environmental Radiation Monitoring

The INEEL OP uses a combination of instruments that measure the environmental radiation levels from natural cosmic and terrestrial sources as well as from possible contributions from operations at the INEEL. The INEEL OP can therefore report the results of measurements of both time-dependent exposure and time-integrated exposure to environmental gamma radiation.

Gamma Radiation Monitoring Locations

Local climatology and atmospheric dispersion models for the INEEL influenced the selection of the locations for the initial radiation monitoring sites in much the same way that such modeling techniques facilitated the placement of the air monitoring stations. Since 1995, the network has included the 14 stations identified in **Figure 2-2**.

Penetrating Radiation Monitoring Equipment and Procedures

The gamma radiation monitoring instrumentation located at each station is listed in **Table 2-3**. The majority of the gamma radiation stations are co-located with air monitoring sites.

Environmental Dosimeters

Environmental dosimeters (EIC) are deployed at radiation monitoring stations to measure cumulative exposure to penetrating radiation in milliRoentgens (mR). Average exposure rates in microRoentgens per hour (µR/hr) are reported using the cumulative exposure divided by the deployment time. The EICs are constructed from carbon-filled polypropylene that offers a nearly air-equivalent response. Before deployment, each EIC's initial voltage is read and recorded. The EIC is then packaged in a mylar plastic bag which is heat sealed. After being labeled, the bag is placed in a tyvek envelope for protection from the elements. At the end of each calendar quarter, the exposed environmental dosimeters are collected, final voltages are read and recorded, and gamma radiation exposures are calculated.

Table 2-3. External radiation monitoring locations, 2001

Instrumentation:	Environmental Dosimeter (EIC)	High-Pressurized Ion Chamber (HPIC)
Analysis	**Gamma (µR/hr)**	**Gamma (µR/hr)**
Onsite Locations		
Base of Howe Peak	✔	✔
Big Lost River Rest Area	✔	✔
Experimental Field Station	✔	
Main Gate	✔	✔
Rover	✔	✔
Sand Dunes	✔	✔
Van Buren Ave.	✔	
Boundary Locations		
Atomic City	✔	✔
Big Southern Butte	✔	✔
Howe Met Tower	✔	✔
Monteview	✔	✔
Mud Lake	✔	✔
Distant Locations		
Idaho Falls	✔	✔
Craters of the Moon	✔	

High-Pressure Ion Chambers (HPICs)

At the 11 monitoring sites identified in **Table 2-3**, high-pressure ion chambers (HPICs) continuously measure the gamma radiation exposure rate in microRoentgens per hour (µR/hr). INEEL OP also uses the data from the HPIC at Fort Hall operated by the Shoshone-Bannock Tribes shown in **Figure 2-2**. Exposure rates are measured every five seconds, and then averaged over five-minute intervals by the data system associated with

each HPIC. Each station is equipped with data loggers, as well as a radio telemetry system for transmitting the five-minute values to the INEEL OP Idaho Falls office.

Gamma Radiation Monitoring Quality Assurance/ Quality Control

Quality control for the gamma radiation monitoring program is maintained through adherence to the INEEL OP standard operating procedures. The INEEL OP routinely conducts quality control checks for all gamma radiation instrumentation and analyses. Each quarter, INEEL OP has EICs irradiated with known gamma exposures for QA purposes. Irradiations of EICs are conducted by ISU EML to a known exposure of 30 milliRoentgen (mR) plus a "blind" exposure of 20 to 50 mR. EIC response is considered acceptable if the measured exposure is within 10% or 3 standard deviations of the actual exposure. In addition, each quarter a second EIC is placed at some monitoring sites to evaluate the reproducibility of the exposure measurement.

The response of each HPIC is verified annually in the field with a radiation source and a calibrated reference instrument. At every location, side-by-side measurements are made of the source with the reference instrument and with the HPIC. Whenever these measurements do not agree to within 10%, the HPIC is removed and returned to the manufacturer for service and calibration.

Interprogram Gamma Radiation Monitoring Results and Comparisons

During 2001, the DOE and the INEEL OP did not co-locate HPICs for gamma radiation measurement. However, the INEEL OP co-located EICs with a limited number of thermoluminescent dosimeters (TLD) from the other surveillance programs.

Terrestrial Monitoring

Terrestrial environmental surveillance typically includes examination of several mechanisms that tend to collect and/or accumulate radioactive material in the environment. Such mechanisms include the concentration of important nutrients and minerals by cattle. Cows' milk tends to concentrate iodine, and since cows typically graze over large areas of pasture, radioiodine fallout may be detected in milk at concentrations corresponding to relatively low concentrations in the environment.

The INEEL OP also conducts *in-situ* soil measurements for selected naturally-occurring and man-made, gamma-emitting radionuclides. The locations for soil and milk sampling reflect the consideration of potential source terms, their significance, regional meteorology, and monitoring activities by other programs.

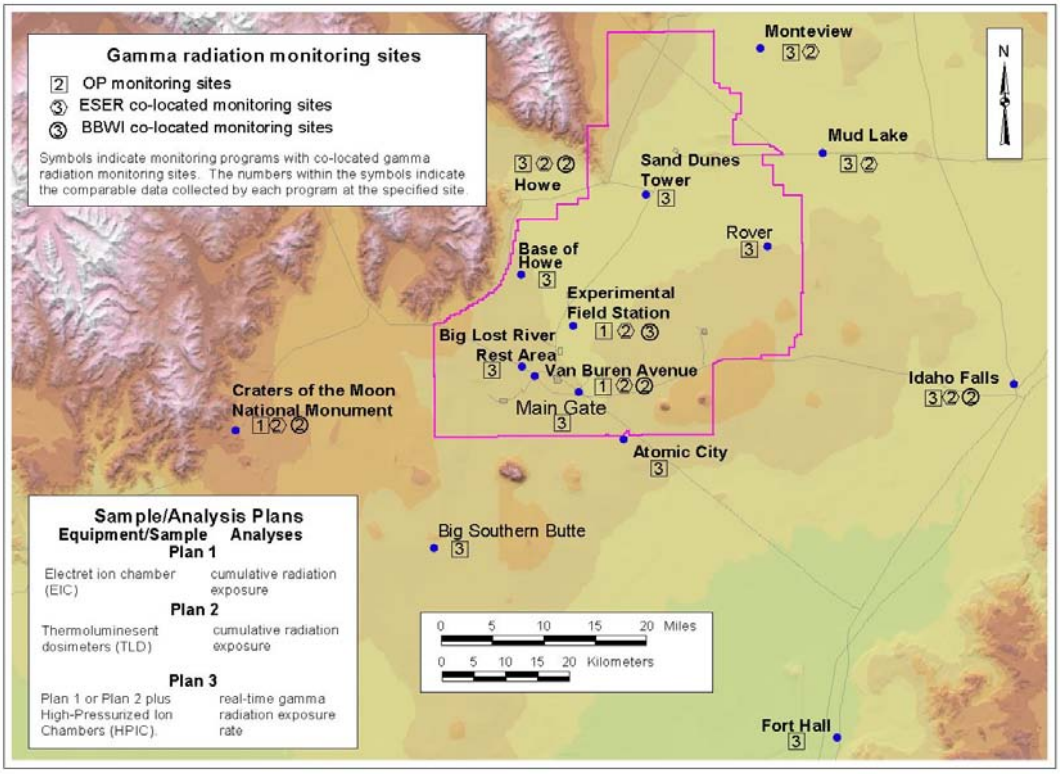


Figure 2-2. Gamma Radiation Monitoring.

Terrestrial Monitoring Locations

Milk Sample Collection Sites and Dairy Locations

Milk samples were collected from five processing plants in Rexburg, Blackfoot, Pocatello, Rupert and Gooding. Each plant processes milk produced by dairies in other localities. For example, the Rexburg plant receives milk originally from dairies in the Howe and Mud Lake areas.

Soil Monitoring Locations

Annually, soil is monitored at INEEL OP's routine air monitoring locations. Performing these measurements at permanent monitoring sites allows the INEEL OP to evaluate the terrestrial component of gamma radiation measurements. In addition, soil measurements are performed at sites co-located with the DOE contractor to verify their analytical results. For 2001, soil was monitored at 17 locations, **Figure 2-4.**

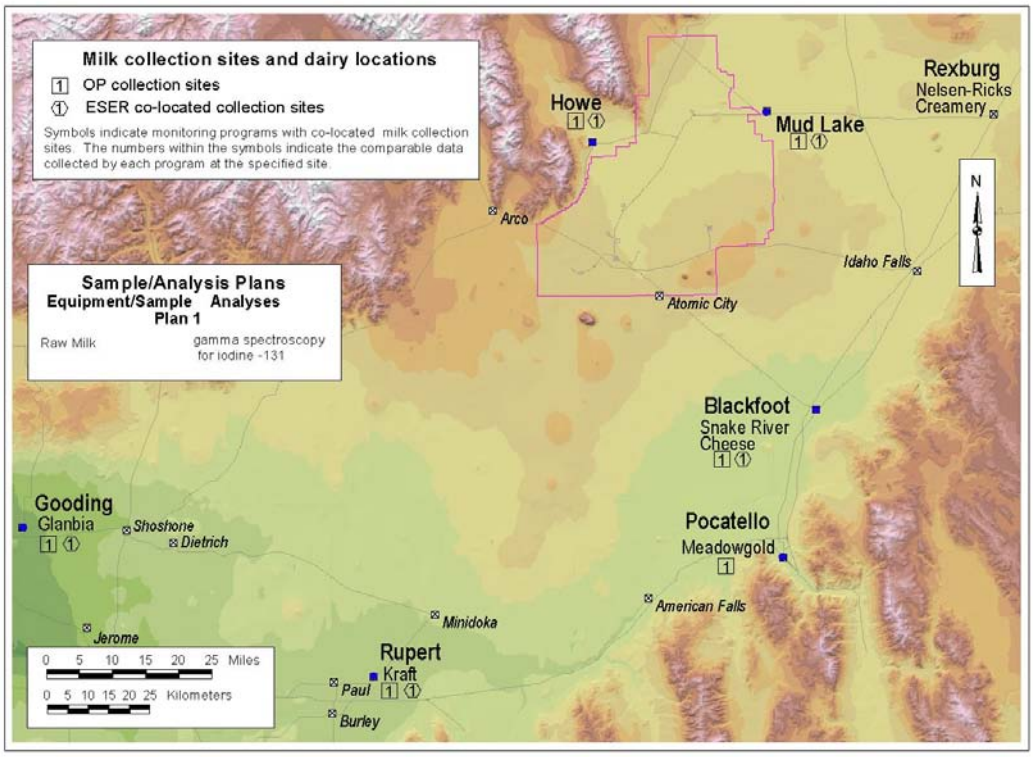


Figure 2-3. Milk Monitoring Locations

Terrestrial Monitoring Equipment and Procedures

Milk Monitoring

Monthly milk samples are collected from fresh dairy shipments after receipt at the processing plants. Two-liter composite samples are collected from each of the five offsite distribution locations. These samples are analyzed by gamma spectroscopy within seven days of collection.

Soil Monitoring

Rather than disturb the soil by physically collecting a sample, the concentration of radionuclides in the soil was measured *in-situ* in the field. Radionuclide concentrations were determined using an intrinsic, high-purity germanium detector assuming the distribution of radionuclides in the soil are homogenous throughout a depth of 0 to 5 cm.

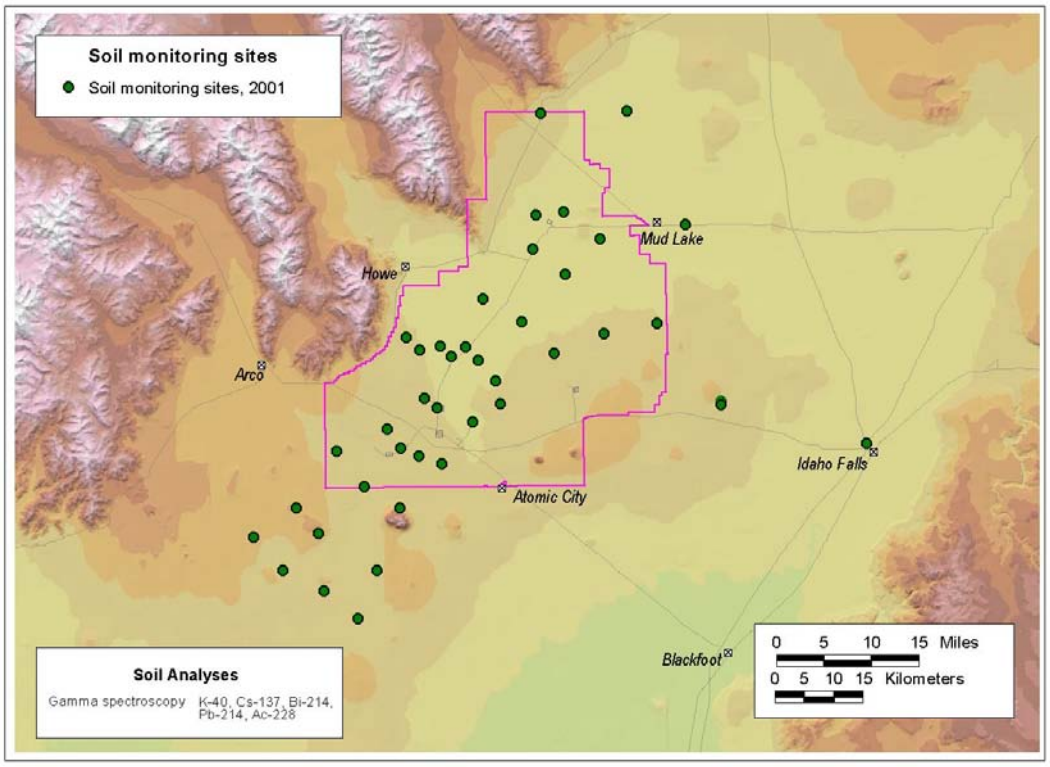


Figure 2-4. Soil Monitoring Locations

Terrestrial Monitoring Quality Assurance/Quality Control

Quality control for the terrestrial monitoring program is maintained through adherence to the INEEL OP standard operating procedures. Laboratory quality assurance and quality control methods include the use of calibration standards, laboratory-prepared spikes, and other technical practices and protocols.

Interprogram Terrestrial Monitoring Results and Comparisons

The INEEL OP collects milk samples after delivery to the distribution centers; currently, ESER collects milk samples from farms prior to shipment.

Water Monitoring

The analyses of water samples collected by the INEEL OP primarily measure concentrations of contaminants known to have been released as liquid effluents from INEEL facilities, but also measure analytes that characterize general water chemistry. Nonradiological analyses are

performed for common ions, nutrients, and dissolved trace metals. Radiological samples undergo analyses for alpha and beta radioactivity, gamma-emitting radionuclides, tritium, strontium-90, technetium-99, uranium and americium-241.

Although very few of the wells sampled by the INEEL OP supply drinking water systems, all analytical results are compared to the EPA's maximum contaminant levels (MCL) or secondary maximum contaminant levels (SMCL). A contaminant's MCL defines the maximum permissible level of that contaminant allowed in a community water system. Concentrations in excess of the MCL may result in adverse impacts to human health or unacceptable risk levels.

A contaminant's SMCL identifies the maximum level that the contaminant can be measured at before the aesthetic qualities of the water are impacted. Although the SMCL is not a legally enforceable limit, concentrations of contaminants that exceed SMCLs may adversely affect the odor, taste, or appearance of water.

The Eastern Snake River Plain Aquifer has been designated as a “sole source” aquifer by the EPA, supplying the majority of drinking water for many Idahoans. Comparing analytical results of water samples taken from the aquifer with MCLs and SMCLs provides a useful means of determining if the quality of this very important source of water is at risk.

Starting in 1999, INEEL OP initiated a verification program in which wastewater and groundwater locations on the INEEL were co-sampled with the primary contractor, ANL-W, or NRF for direct comparison purposes. Nonradiological analyses are performed for common ions, nutrients, trace metals, and volatile organic compounds (VOCs). Radiological samples undergo analyses for alpha and beta radioactivity, gamma-emitting radionuclides, tritium, strontium-90, plutonium isotopes, uranium isotopes, neptunium-237, and technetium-99.

Water Monitoring Locations

The INEEL OP monitors water quality at 88 separate sampling locations for routine sampling and 30 locations for verification. As shown in **Figures 2-5,** and **2-6,** the areas of the routine monitoring locations have been divided into onsite, boundary, distant, Magic Valley, and surface water categories. **Table 2-4** specifies the routine sampling schedules, analyses, and corresponding co-sampling organizations for each of these locations. Wastewater and groundwater verification samples were collected with BBWI, NRF, and ANL-W at several locations on the INEEL (**Figure 2-6)**. **Table 2-5** presents the verification sampling program’s water monitoring schedules and analyses for each location.

Beginning in October 2001, the USGS reduced sampling frequency for most water monitoring sites on the INEEL, resulting in a reduction in the number of water surveillance sites sampled by the INEEL OP. Sites sampled quarterly on the INEEL by the USGS were reduced to semiannual sampling. A selected number of sites sampled semiannually prior to October 2001 were reduced to annual sampling. These sites are Atomic City, P&W 2, Site-14, USGS 8, 19, 27, and USGS 100. The INEEL OP maintained a quarterly schedule for Atomic City, but reduced sampling at the listed sites to annually, corresponding to the USGS sampling frequency. **Table 2-4** does not

reflect this change in sampling frequency. The INEEL OP and ESER both sample at Atomic City and Mud Lake Water Supply, though not necessarily the same day and time.

Water Monitoring Equipment and Procedures

Prior to each sample collection, the well is pumped to remove standing water in the borehole and any associated plumbing such as the pressure tank and discharge line. During the purge of the well, measurements of the pH, specific conductance, and water temperature are monitored.. After these parameters have stabilized and approximately three well-bore volumes have been pumped, the sample is collected, always from the same designated sampling port.

Surface water samples from the Big Lost River, Birch Creek, and the springs distant from the INEEL in Magic Valley are routinely collected in areas of moving water, in order to collect samples representative of the bulk of the stream.

Water Monitoring Quality Assurance/Quality Control

Quality control for the water monitoring program is maintained through adherence to the INEEL OP standard operating procedures. To verify the accuracy and precision of the laboratory analyses, the INEEL OP obtains analytical results of field duplicates of radiological water samples and both field duplicates and spiked samples of non-radiological water samples.

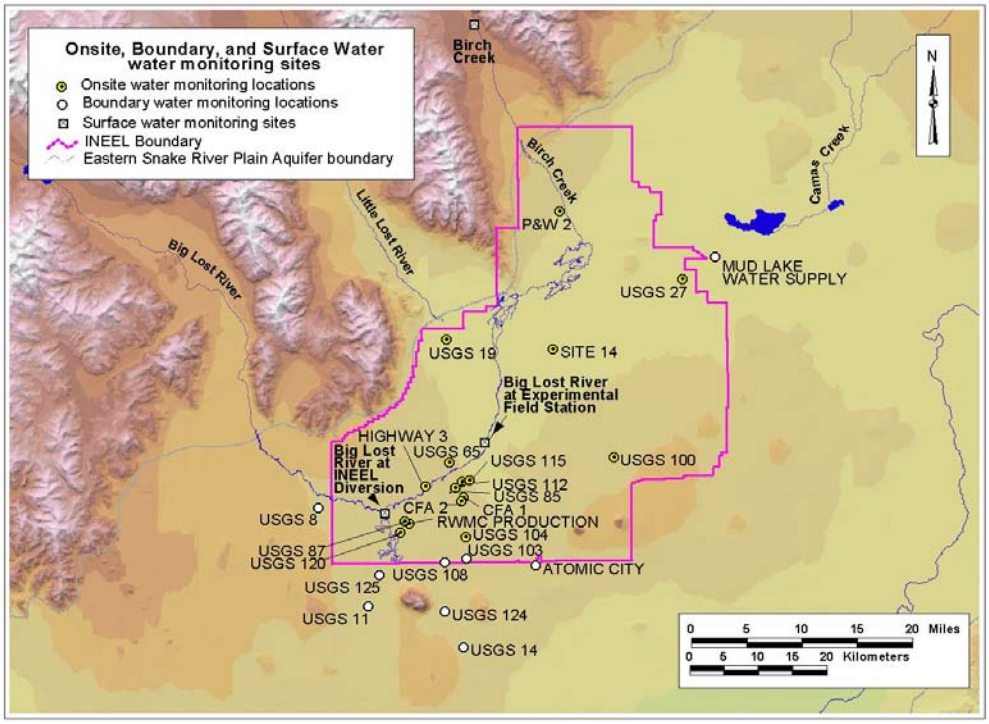


Figure 2-5. Onsite and Boundary Water Monitoring Locations

Inter-program Water Monitoring Results and Comparisons

Comparisons of INEEL OP, ESER, USGS, BBWI, ANL-W, and NRF results involve the collection of replicate samples—samples collected by two of the agencies at essentially the same time, typically less than a few minutes apart. The only exceptions to this are results from Mud Lake Water Supply and Atomic City for the second and fourth quarters.

Because goals for the water sampling programs conducted by the various agencies may differ, all samples are not analyzed for exactly the same parameters by all agencies. As previously discussed, separate laboratories perform these analyses, and certain differences in analytical methods can influence the comparisons of inter-program results.

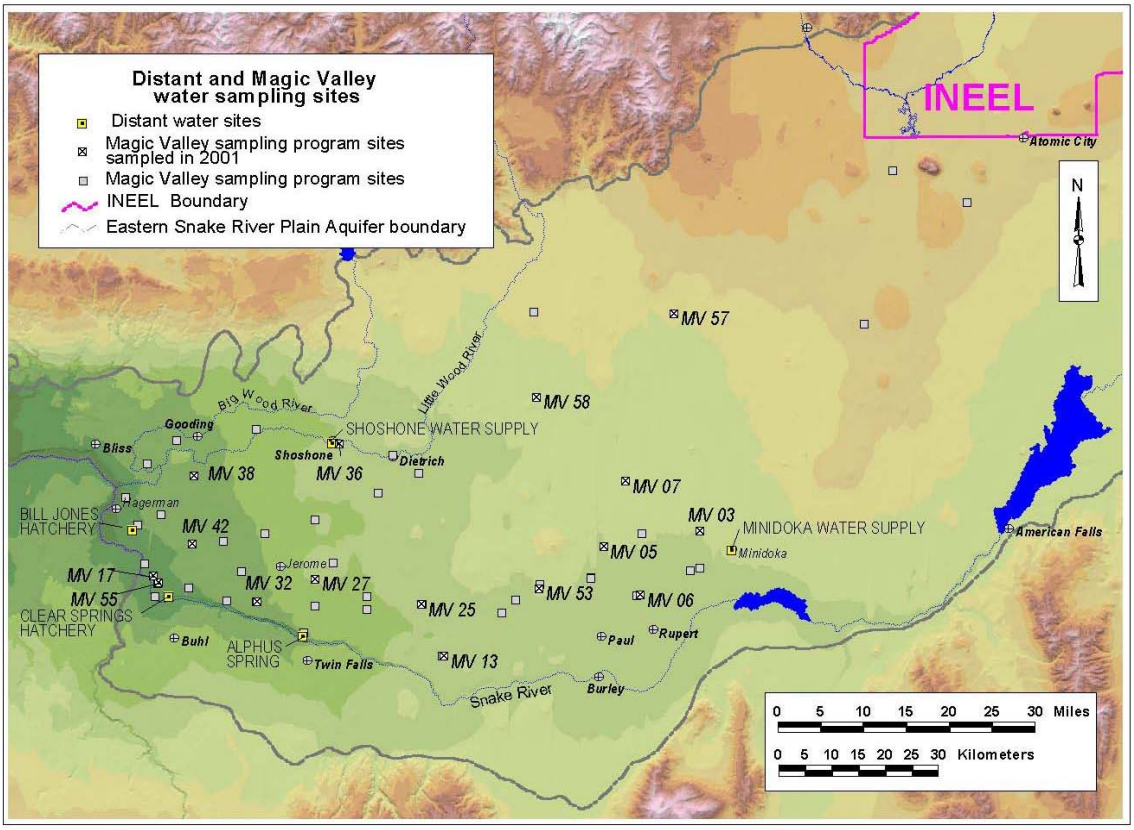


Figure 2-6. Distant and Magic Valley Water Sampling Locations

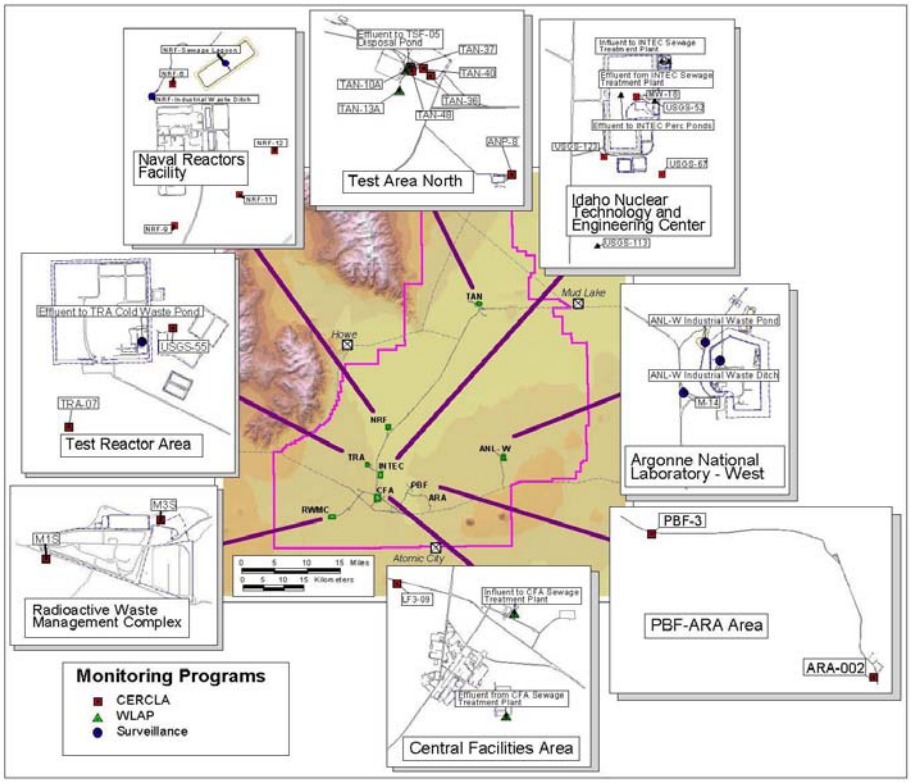


Figure 2-7. Water Verification Monitoring Sites

Table 2-4. Inter-program water monitoring sampling schedules and analyses, 2001

Co-located/Replicate Sample Analyses		Radiological		Nonradiological		
Analysis	**Frequency***	**Alpha, Beta, Gamma**	**Tritium**	**Metals**	**Common Ions`**	**Nutrients**
Onsite Locations			**Organizations**			
CFA 1	Q	OP	OP USGS	OP USGS	OP USGS	OP USGS
CFA 2	Q	OP	OP USGS	OP USGS	OP USGS	OP USGS
RWMC Production	Q	OP	OP	OP	OP USGS	OP USGS
P&W 2	S	OP USGS	OP USGS	OP USGS[a]	OP USGS	OP USGS
Site 14	S	OP USGS	OP USGS	OP USGS[a]	OP USGS	OP USGS
USGS 19	S	OP USGS	OP USGS	OP USGS[a]	OP USGS	OP USGS
USGS 27	S	OP USGS	OP USGS	OP USGS[a]	OP USGS	OP USGS
USGS 65	Q	OP USGS	OP USGS	OP	OP USGS	OP USGS
USGS 85	S	OP	OP USGS	OP	OP USGS	OP USGS
USGS 87	Q	OP USGS	OP USGS	OP USGS[a]	OP USGS	OP USGS
USGS 100	S	OP	OP USGS	OP USGS[a]	OP USGS	OP
USGS 104	Q	OP	OP USGS	OP	OP USGS	OP USGS
USGS 112	Q	OP	OP USGS	OP	OP USGS	OP USGS

Table 2-4. Inter-program water monitoring sampling schedules and analyses, 2001

Co-located/Replicate Sample Analyses		Radiological		Nonradiological		
Analysis	**Frequency** *	**Alpha, Beta, Gamma**	**Tritium**	**Metals**	**Common Ions`**	**Nutrients**
USGS 115	Q	OP	OP USGS	OP	OP USGS	OP USGS
USGS 120	Q	OP USGS	OP USGS	OP USGS[a]	OP USGS	OP USGS
Boundary Locations				**Organizations**		
Atomic City	Q/S	OP ESER[c]	OP USGS ESER	OP	OP USGS	OP USGS
Highway 3	S	OP USGS	OP USGS	OP USGS[a]	OP USGS	OP USGS
Mud Lake Water Supply	Q	OP ESER[c]	OP ESER[c]	OP	OP	OP
USGS 8	S	OP USGS	OP USGS	OP USGS[a]	OP USGS	OP USGS
USGS 11	S	OP USGS	OP USGS	OP USGS[a]	OP USGS	OP USGS
USGS 14	S	OP USGS	OP USGS	OP USGS[a]	OP USGS[b]	OP USGS
USGS 103	Q	OP USGS	OP USGS	OP USGS[a]	OP USGS	OP USGS
USGS 108	S	OP USGS	OP USGS	OP USGS[a]	OP USGS	OP USGS
USGS 124	S	OP	OP USGS	OP	OP USGS	OP
USGS 125	S	OP	OP USGS	OP USGS[a]	OP USGS	OP USGS
Distant Locations				**Organizations**		
Alpheus Spring	Q/S	OP ESER[c]	OP ESER	OP**	OP**	OP**
Bill Jones Hatchery	Q/S	OP ESER[c]	OP ESER	OP**	OP**	OP**
Clear Spring	Q/S	OP ESER[c]	OP ESER	OP**	OP**	OP**
Minidoka Water Supply	Q/S	OP ESER[c]	OP ESER	OP**	OP**	OP**
Shoshone Water Supply	Q/S	OP ESER[c]	OP ESER	OP**	OP**	OP**
Magic Valley Sampling Program				**Organizations**		
MV 01	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 02	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 03	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 04	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 05	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 06	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 07	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 09	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 10	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 11	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 12	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 13	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 14	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 15	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 16	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 17	T	OP USGS[c]	OP USGS	USGS	USGS	USGS

Table 2-4 continued. Inter-program water monitoring sampling schedules and analyses, 2001

Co-located/Replicate Sample Analysis		Radiological		Nonradiological		
Analysis	Frequency *	Alpha, Beta, Gamma	Tritium	Metals	Common Ions	Nutrients
MV 18	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 19	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 20	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 21	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 23	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 24	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 25	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 26	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 27	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 29	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 30	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 31	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 32	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 33	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 35	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 36	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 37	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 38	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 39	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 40	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 41	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 42	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 43	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 45	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 46	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 47	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 48 (USGS 11)	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 49	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 50	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 51	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 52	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 53	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 54	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 55	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 56	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 57	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 58	T	OP USGS[c]	OP USGS	USGS	USGS	USGS

Table 2-4 continued. Inter-program water monitoring sampling schedules and analyses, 2001

Co-located/Replicate Sample Analysis		Radiological		Nonradiological		
Analysis	**Frequency***	**Alpha, Beta, Gamma**	**Tritium**	**Metals**	**Common Ions**	**Nutrients**
MV 59	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
MV 61 (USGS 14)	T	OP USGS[c]	OP USGS	USGS	USGS	USGS
Surface Water Locations		**Organizations**				
Birch Creek at Blue Dome	S	OP	OP USGS	OP	OP USGS	OP USGS
Big Lost River at Experimental Field Station	S	OP USGS	OP USGS	OP USGS	OP USGS	OP USGS
Big Lost River at INEEL Diversion	S	OP USGS	OP USGS	OP USGS	OP USGS	OP USGS

* Sampling Frequency Abbreviations: Q = Quarterly S = Semiannually T = Triennially
Q/S = Quarterly by OP, semiannually by USGS

** OP collects samples that are analyzed for metals, chloride, and nutrients at these distant sites annually.

[a] The USGS samples only for chromium at these locations; the OP samples for all the metals listed in the text.
[b] The USGS samples only for chloride at these location; the OP samples for all the common ions listed in the text.
[c] The specified co-sampling organization does not analyze samples from these sites by gamma spectroscopy.

Table 2-5. Verification sampling program's water monitoring schedules and analyses, 2001

Location/Analytes	Sampling Frequency[1]	Radiological[2]	Nonradiological	
			Inorganics[3]	VOCs[4]
Wastewater				
ANL-W Industrial Waste Ditch	A	X	X	
ANL-W Industrial Waste Pond	A	X	X	
Influent to CFA sewage treatment facility	A		X	
Effluent from CFA sewage treatment facility	A	X	X	
Influent to INTEC sewage treatment facility	A		X	
Effluent from INTEC sewage treatment facility	A	X	X	
INTEC Percolation Ponds	A	X	X	
NRF Industrial Waste Ditch	T	X	X	
NRF Sewage Lagoon	S	X	X	
TAN Disposal Pond	A	X	X	
TRA Cold Waste Pond	A	X	X	
Groundwater				
ANL-MON-A-014	A	X	X	
ARA-MON-A-002	A	X	X	X
LF2-09	A	X	X	X
M1SA	Q	X	X	X
M3S	Q	X	X	X
NRF-6	A	X	X	X
NRF-9	A	X	X	X
NRF-11	A	X	X	X
NRF-12	A	X	X	X
PBF-MON-A-003	A	X	X	X
TAN-10A	A		X	
TAN-13A	A		X	
TRA-7	A	X	X	
USGS-52	A	X	X	
USGS-55	A	X	X	
USGS-67	A	X	X	
USGS-123	A	X	X	

1. Sampling Frequency Abbreviations: A=annually, q=quarterly, S=semiannually, T=tri-annually
2. Radiological analyses include one or more of the following: americium-241, gamma spectroscopy, gross alpha radioactivity, gross beta radioactivity, neptunium-237, plutonium isotopes, strontium-90, technetium-99, tritium, and uranium isotopes.
3. Inorganic analyses include various metals, common ions, and nutrients.
4. volatile organic compounds

Chapter 3
Air Monitoring

Major Findings and Developments

Measurements of radionuclides in air were consistent with historical background concentrations. Gross alpha and gross beta screening measurements, atmospheric tritium concentrations, and tritium concentrations in precipitation were consistent with the range of historical background concentrations and typically below detection levels.

- No offsite environmental impacts from INEEL operations were evident as a result of particulate air sampling using PM_{10} and TSP samplers.
- Strontium-90 was measured at several monitoring locations. Concentrations were slightly greater than the laboratory's detection capability, yet were significantly below the INEEL OP action level.
- Radioactive iodine was not detected in air samples as observed in past years.
- No offsite environmental impacts from INEEL operations were detected in precipitation samples.
- Tritium was measured in one atmospheric moisture sample collected at a boundary location. The concentration was slightly greater than the laboratory's detection capability.
- Comparison between PM_{10} sampling data and TSP sampling data collected shows relatively good agreement.
- Interprogram comparisons of different surveillance program results show poor to relatively good agreement. Discrepancies have been traced to differences in sampling methodologies, schedules, and laboratory detection capabilities.

Primary Air Results and Trends

INEEL OP collects particulate air samples weekly. During the 2001 calendar year, INEEL OP investigated an alternative to the aging PM_{10} samplers used for the past several years. Availability of replacement and maintenance parts for aging PM_{10} samplers indicated a need for an alternative with "off-the-shelf" components for easy repair and replacement. Data collected with these alternative samplers, high volume total suspended particulate (TSP) samplers, are

included in the data comparison with BBWI and ESER air monitoring programs at the end of this chapter.

Routine air monitoring includes the collection of particulate filters on a weekly basis and analyses of these filters in a timely manner, using a gross screening analysis (gross alpha and gross beta). Gross screening analyses of air filters collected during 2001 indicated the presence of radioactive material at concentrations associated with radionuclides found naturally in the environment (**Table 3-1**). Gross alpha concentrations slightly exceeded the INEEL OP action level (0.0021 pCi/m^3 corresponding to 5 mrem [50 μSv] per year assuming all alpha activity is from americium-241) on several occasions at onsite, boundary, and distant monitoring locations. It is likely that the cause was due to elevated concentrations of radon progeny, specifically polonium-210. Gamma spectroscopic analysis did not indicate the presence of man-made radionuclides. Also, americium-241, plutonium-238, and plutonium-239/240 were not detected at the locations that experienced elevated gross alpha activity.

Table 3-1. Descriptive statistics for 2001 particulate air sampling gross screening results from PM_{10} samplers. TSP results are shown in parentheses for comparison purposes.

	Gross Alpha (pCi/m^3)	Gross Beta (pCi/m^3)	PM_{10} (μg/m^3)
Boundary Locations			
Average Value:	0.0011 (0.0008)	0.039 (0.024)	10.4
Median Value:	0.0011 (0.0008)	0.032 (0.022)	9.8
Standard Deviation:	0.0004 (0.0003)	0.021 (0.010)	4.8
Minimum Value:	0.0001 (0.0002)	0.009 (0.008)	0.4
Maximum Value:	0.0024 (0.0017)	0.123 (0.066)	31.4
Distant Locations			
Average Value:	0.0011 (0.0008)	0.031 (0.021)	11.4
Median Value:	0.0011 (0.0007)	0.029 (0.020)	10.6
Standard Deviation:	0.0006 (0.0004)	0.015 (0.010)	6.1
Minimum Value:	0.0000 (0.0001)	0.008 (0.006)	0.3
Maximum Value:	0.0032 (0.0021)	0.086 (0.056)	32.6
Onsite Locations			
Average Value:	0.0010 (0.0009)	0.037 (0.026)	9.3
Median Value:	0.0010 (0.0009)	0.032 (0.025)	7.5
Standard Deviation:	0.0005 (0.0004)	0.020 (0.010)	7.2
Minimum Value:	0.0000 (0.0003)	0.005 (0.012)	1.0
Maximum Value:	0.0030 (0.0031)	0.127 (0.078)	55.8

Each year including 2001, gross beta activity tends to increase during winter months (**Figure 3-1**). Elevated gross beta measurements are attributed to temperature inversions that hold radon progeny in the lower portion of the atmosphere.

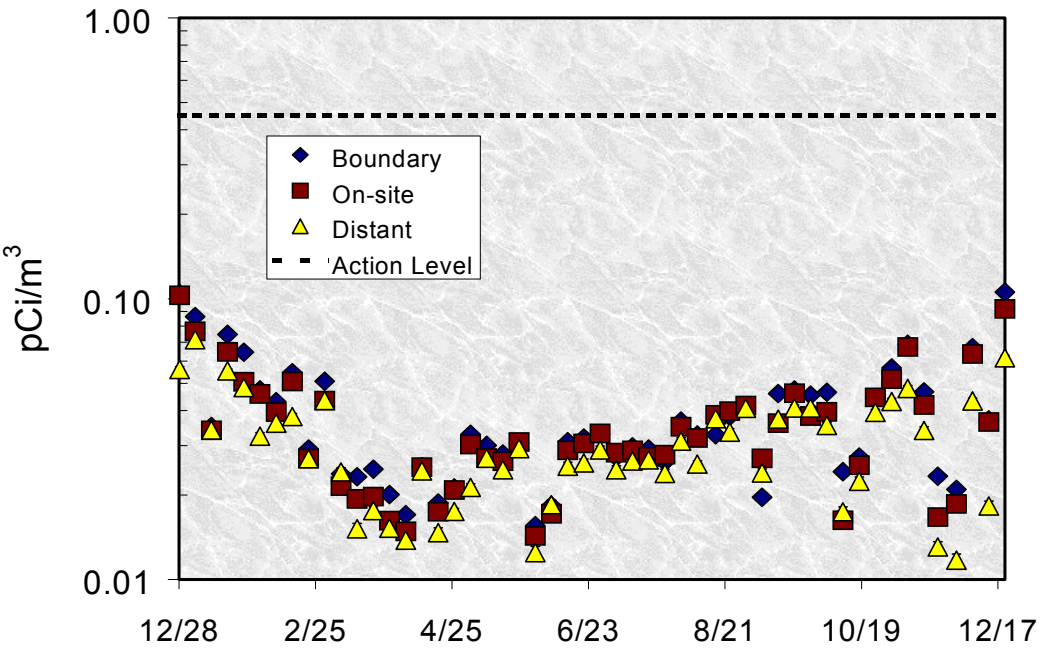


Figure 3-1. Gross beta screening results of PM_{10} filters (log scale) collected during 2001. The dotted line corresponds to the gross beta Action Level, 0.45 pCi/m^3. This concentration corresponds to approximately 1 mrem per year (10 μSv per year) assuming all of the activity is due to strontium-90 and remains constant for an entire year.

Radioiodine filters are collected weekly and analyzed via gamma spectrometry in a timely manner to account for the 8-day half-life of iodine-131. No iodine-131 was detected in activated charcoal filters used for sampling radioiodine during 2001.

Quarterly composites of particulate air samples are analyzed via gamma spectroscopy for gamma-emitting radionuclides. No man-made radionuclides were observed during 2001. Several naturally-occurring radionuclides, including beryllium-7, were observed. The concentrations of beryllium-7 provide insight as to the degree of atmospheric mixing taking place between the upper and lower atmosphere. Decreased beryllium-7 concentrations are expected during winter months as a result of poor atmospheric mixing during temperature inversions (**Figure 3 -2**).

Annual composite samples are analyzed for transuranic radionuclides, including americium-241 plutonium-238, plutonium-239/240, and strontium-90. No transuranic radionuclides were detected on annual composites of filters collected with the exception of plutonium-239/240 measured on the PM_{10} composite collected at the distant or "background" location at Craters of the Moon National Monument. The reported measurement was less than 3% of the INEEL OP action level and was rejected since plutonium-239/240 was not measured on the TSP composite collected at the same location during the same sampling period.

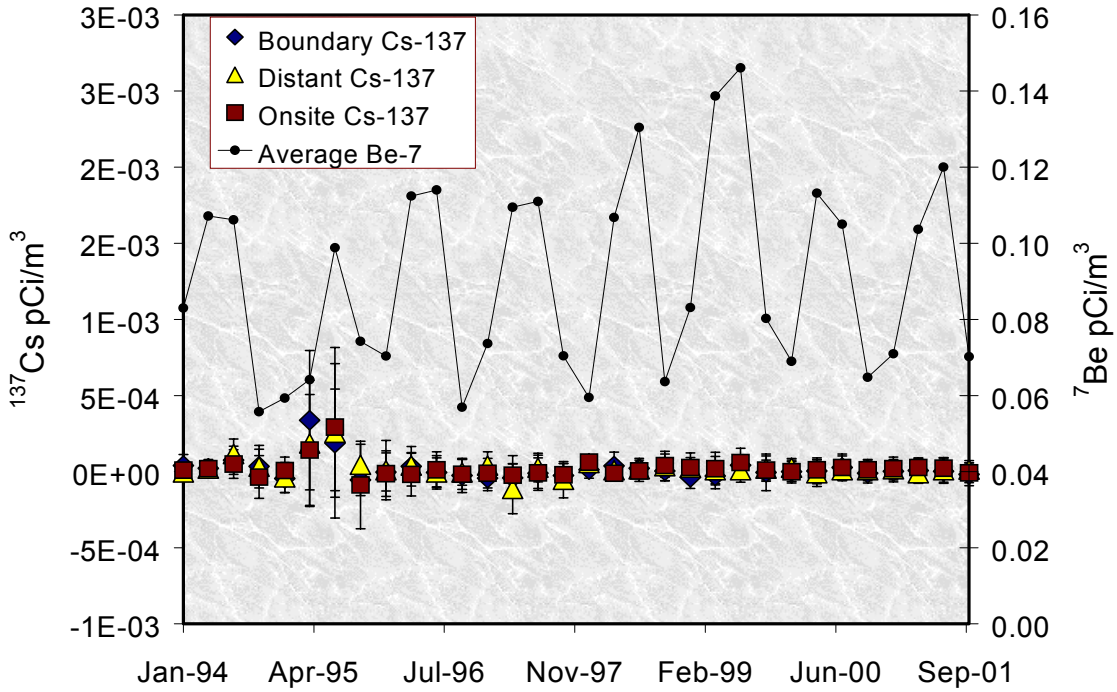


Figure 3-2. Historical gamma spectroscopic analysis results including quarterly averages of beryllium-7 concentrations observed at all locations and average cesium-137 concentrations reported from onsite, boundary, and distant monitoring locations. Note the seasonal fluctuation for beryllium-7 concentrations indicating changes in atmospheric mixing. Error bars with the cesium-137 concentrations represent 2-sigma counting uncertainty.

Strontium-90 was detected on several filter composites at concentrations well below the INEEL OP action level of 0.45 pCi/m^3 or 1 mrem (10 μSv) per year. Strontium-90 concentrations are shown in **Table 3-2**.

Atmospheric Moisture and Precipitation

INEEL OP uses a molecular sieve desiccant to collect atmospheric moisture. The moisture samples are then analyzed for tritium. Using field data and tritium concentrations in water vapor collected, atmospheric tritium concentrations are calculated assuming atmospheric tritium is found in the environment in the form of tritiated water vapor ($HTO_{(g)}$). Atmospheric moisture is collected at 11 sampling locations with measurements from Craters of the Moon National Monument, Idaho Falls, and at the Fort Hall Environmental Monitoring Station used as reference background if tritium concentrations significantly exceed detection capabilities. Average atmospheric tritium measurements are shown in **Figure 3-3** including data collected since April 1994.

Tritium was detected in atmospheric moisture samples collected at three onsite monitoring locations, Experimental Field Station, Van Buren, Big Lost River Rest Area), and one boundary monitoring location, Monteview, during 2001.

Table 3-2. 2001 strontium-90 concentrations in particulate air samples

	Sr-90 (pCi/m^3)	Sr-902-sigma [1] (pCi/m^3)	Sr-90 MDC (pCi/m^3)	Percent of Action Level
PM_{10} Samples				
Atomic City	0.000008	0.000010	0.000016	
Van Buren Avenue	0.000048	0.000030	0.000041	0.11%
Craters of the Moon National Monument	0.000026	0.000027	0.000043	
Experimental Field Station	0.000020	0.000023	0.000038	
Howe	0.000006	0.000021	0.000039	
Idaho Falls	0.000002	0.000020	0.000038	
Mud Lake/Terreton	0.000015	0.000019	0.000031	
Fort Hall	0.000049	0.000032	0.000045	0.11%
Rest Area	0.000034	0.000021	0.000029	0.0.8%
Sand Dunes Tower	0.000044	0.000029	0.000040	0.10%
Monteview	0.000030	0.000024	0.000036	
Blank	0.000011	0.000019	0.000033	
TSP Samplers				
Atomic City	0.000005	0.000005	0.000008	
Van Buren Avenue	0.000029	0.000015	0.000018	0.06%
Craters of the Moon National Monument	0.000027	0.000015	0.000020	0.06%
Experimental Field Station	0.000006	0.000005	0.000008	
Howe	0.000007	0.000013	0.000022	
Idaho Falls	0.000030	0.000015	0.000018	0.07%
Mud Lake/Terreton	0.000023	0.000013	0.000017	0.05%
Rest Area	0.000053	0.000020	0.000022	0.12%
Sand Dunes Tower	-0.000001	0.000005	0.000009	
Monteview	0.000022	0.000011	0.000015	0.05%
Blank	0.000006	0.000010	0.000017	

[1] 2-sigma counting uncertainty

The atmospheric tritium concentrations measured at the onsite locations may be due, in part, to the dry storage facility for the Three Mile Island fuel fragments being stored at INTEC. Atmospheric tritium concentrations ranged from less than MDC to 1.65 ± 0.66 pCi/m^3. Historically, the detection capabilities for atmospheric tritium have ranged from 0.5 to 5.0 pCi/m^3 depending on humidity, volume of air sampled, and the laboratory MDC for tritium in the atmospheric moisture. The atmospheric tritium concentrations measured at the onsite locations and at the boundary location are significantly below the INEEL OP action level (790 pCi/m^3).

Precipitation samples are analyzed for tritium and for gamma-emitting radionuclides that may have undergone atmospheric wash out. No tritium or man-made, gamma-emitting radionuclides were observed in precipitation samples collected during 2001. Average tritium concentrations are presented in **Figure 3-4**.

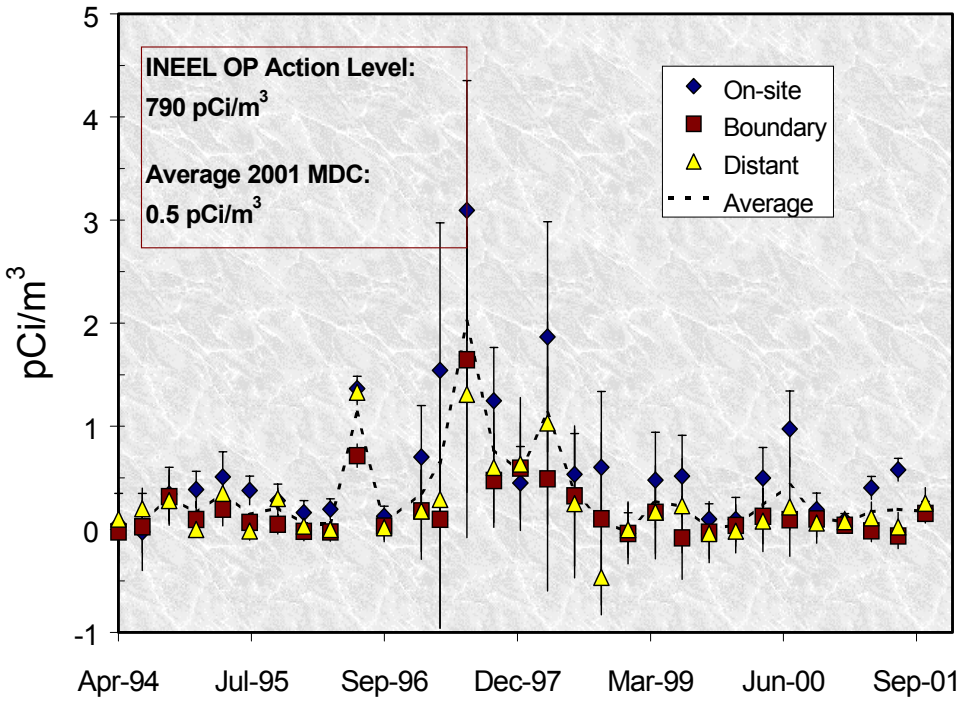


Figure 3-3. Average quarterly atmospheric tritium concentrations since April 1994. These measurements are significantly less than the INEEL OP Action Level corresponding to 1 mrem (10 µSv) per year or 790 pCi/m^3.

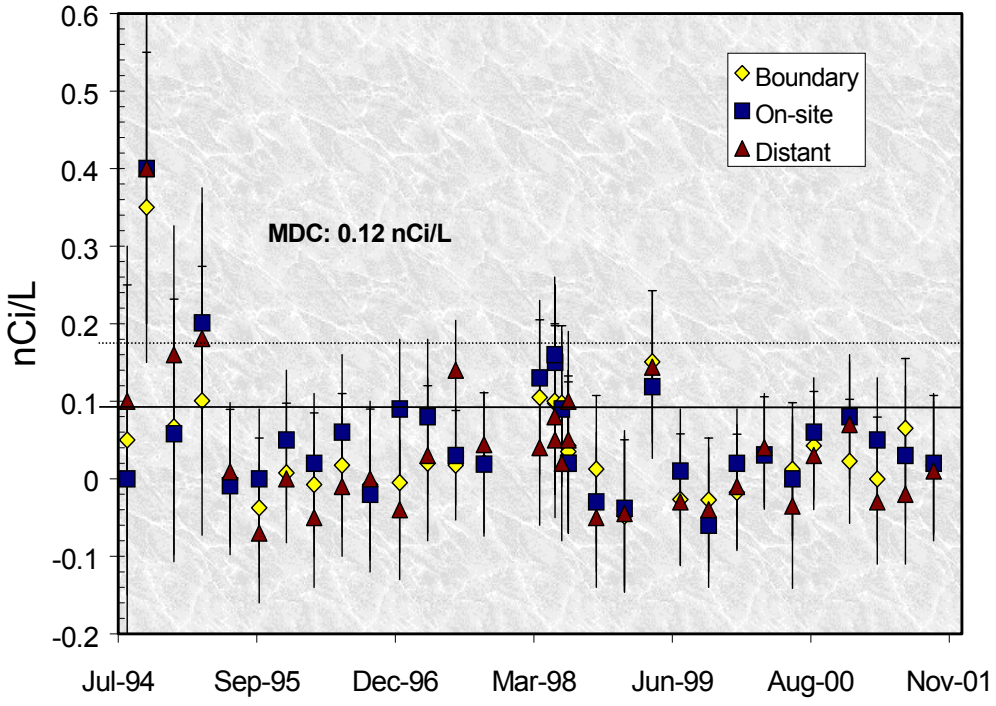


Figure 3-4. Average tritium concentrations in precipitation samples collected by INEEL OP since the second calendar quarter of 1994. The dotted line represents the typically reported detection capability for tritium during 2001.

Interprogram Comparisons of Air Sampling Results

BBWI, ESER, and INEEL OP conduct air monitoring by collecting particulate air filters and radioiodine samplers on a weekly basis. Particulate air filters are subjected to gross alpha and gross beta screening analyses and activated charcoal (radioiodine) samplers are analyzed via gamma spectroscopy for iodine-131. Quarterly composites of particulate air filters are analyzed via gamma spectroscopy and annual composites of particulate air filters are analyzed via radiochemical separation for specific radionuclides such as strontium-90 that cannot be identified via gamma spectroscopy. Air sampling also involves the collection of atmospheric moisture to determine atmospheric tritium concentrations.

Since air-sampling methodologies vary slightly between programs, the results of direct comparisons of screening analyses (e.g., gross alpha and gross beta concentrations in air) are difficult to quantify and interpret. Gamma spectroscopic analyses of composite air filter samples did not show measurable quantities of man-made, gamma-emitting radionuclides. No iodine-131 was detected in activated charcoal air filters collected by the INEEL OP, BBWI, or ESER during routine environmental surveillance for 2001.

The comparisons of other constituents show relatively poor agreement to relatively good agreement. Variability among the three surveillance programs may be due to differing sampling procedures and schedules in addition to variations in laboratory analytical procedures. Poor agreement is not entirely unexpected due to the extremely low concentrations reported and variations in natural background. Despite variations in reported analysis results, neither BBWI nor ESER observed measurable impacts to the environment as a result of INEEL operations during 2001.

Gross Alpha and Gross Beta Radioactivity Comparison Results

The comparison of gross alpha and gross beta concentrations observed by INEEL OP with respect to concentrations observed by ESER or BBWI was performed using data collected from air monitoring stations located at Craters of the Moon National Monument, Experimental Field Station, Idaho Falls, and Van Buren Avenue. Craters of the Moon National Monument and Idaho Falls are considered distant sampling locations, while the Experimental Field Station and Van Buren Avenue are onsite sampling locations.

Descriptive statistics of gross alpha and gross beta radioactivity results used for comparison purposes are shown in **Table 3-3**. Differences in gross screening results are attributable to differences in sampling methods, sampling schedules, and laboratory analysis methods.

Table 3-3. Descriptive statistics for comparison between gross alpha and gross beta screening analysis results for INEEL OP (TSP and PM_{10} samplers), ESER, and BBWI

	Gross Alpha (pCi/m^3)			
	OP TSP	**OP PM_{10}**	**ESER**	**BBWI**
Average Value:	0.0010	0.0008	0.0018	0.0004
Median Value:	0.0010	0.0008	0.0018	0.0004
Standard Deviation:	0.0004	0.0003	0.0007	0.0008
Minimum Value:	0.0003	0.0003	0.0003	-0.0016
Maximum Value:	0.0020	0.0014	0.0032	0.0019
	Gross Beta (pCi/m^3)			
	OP TSP	**OP PM_{10}**	**ESER**	**BBWI**
Average Value:	0.0241	0.0347	0.0313	0.0279
Median Value:	0.0216	0.0292	0.0298	0.0260
Standard Deviation:	0.0090	0.0171	0.0120	0.0106
Minimum Value:	0.0115	0.0135	0.0118	0.0110
Maximum Value:	0.0550	0.0832	0.0718	0.0653

Gross alpha and gross beta analyses of particulate air samples are screening tools. As screening analyses, specific radionuclides are not identified, and measurements are not decay-corrected. Mass absorption corrections, due to impracticality, are not performed. However, while these variations will frequently indicate statistical differences between data sets, quantitative comparison methods make it possible to evaluate the agreement between results. To determine data correlation between programs, INEEL OP examines the relative difference between one measurement and the mean of both programs' measurements. If the absolute value of the relative difference is less than 20% or the two reported values are within 3-standard deviations of the reported uncertainty, the results are considered to be in agreement. Agreement is considered "good" if at least 80% of the paired samples meet these criteria. Discrepancies are expected due to differences in sampling schedules and sampling methodology. Results of these comparisons are shown in **Table 3-4**.

An additional comparison includes a trend analysis of average concentrations reported. **Figures 3-5** and **3-6** show average weekly gross alpha and gross beta concentrations, respectively, from Craters of the Moon National Monument, Experimental Field Station, Idaho Falls, and Van Buren Avenue monitoring stations observed by INEEL OP, ESER, and BBWI. Even though the reported values differ, overall, the values track each other fairly well.

Table 3-4. Summary of comparison between INEEL OP, ESER, and BBWI gross alpha and gross beta screening results of particulate air filters

	INEEL OP PM_{10} samplers vs. BBWI	INEEL OP PM_{10} samplers vs. ESER	ESER vs. BBWI	INEEL OP TSP samplers vs. BBWI	INEEL OP TSP samplers vs.ESER
Gross Alpha					
Average Relative Difference:	6.4%	24.0%	13.2%	14.1%	32.4%
Number of Samples Compared:	194	253	200	190	248
Percent Agreement:	86.6%	89.3%	82.0%	90.0%	79.8%
Gross Beta					
Average Relative Difference:	7.7%	4.0%	5.8%	7.0%	12.8%
Number of Samples Compared:	193	253	201	190	248
Percent Agreement:	67.9%	78.3%	93.5%	85.8%	80.6%

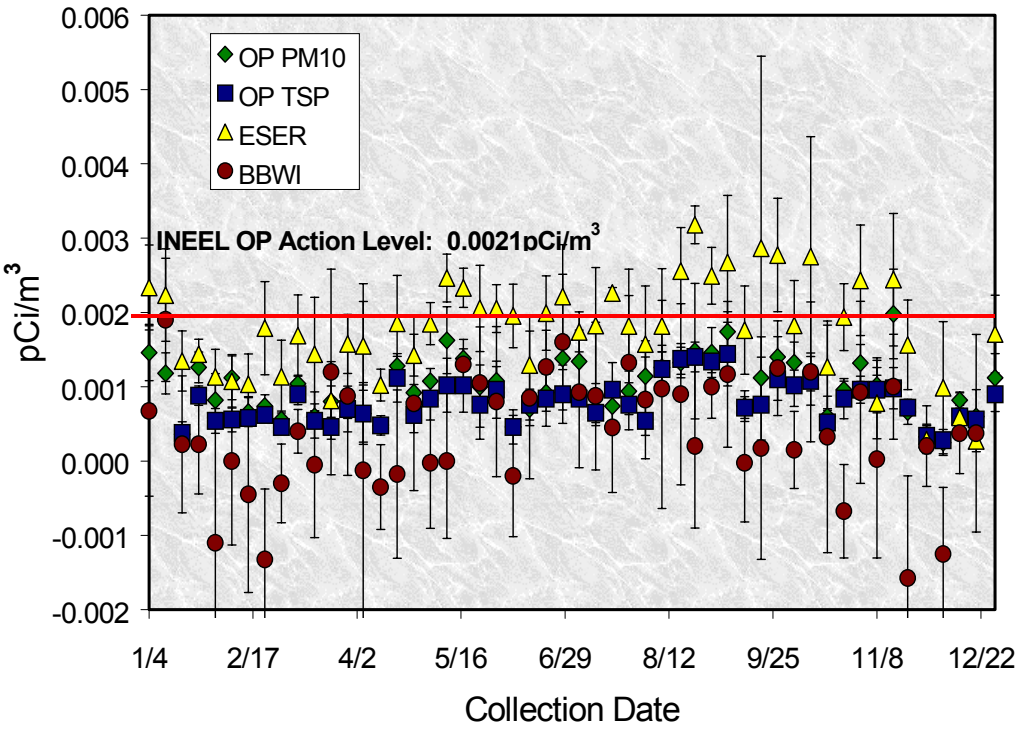


Figure 3-5. Average weekly gross alpha screening results from co-located air samplers operated by INEEL OP, ESER, and BBWI during 2001. The error bars represent 2-sigma counting uncertainty and the INEEL OP Action Level corresponds to 5 mrem (50 µSv) per year assuming all of the gross alpha activity is attributable to Am-241 and remains constant.

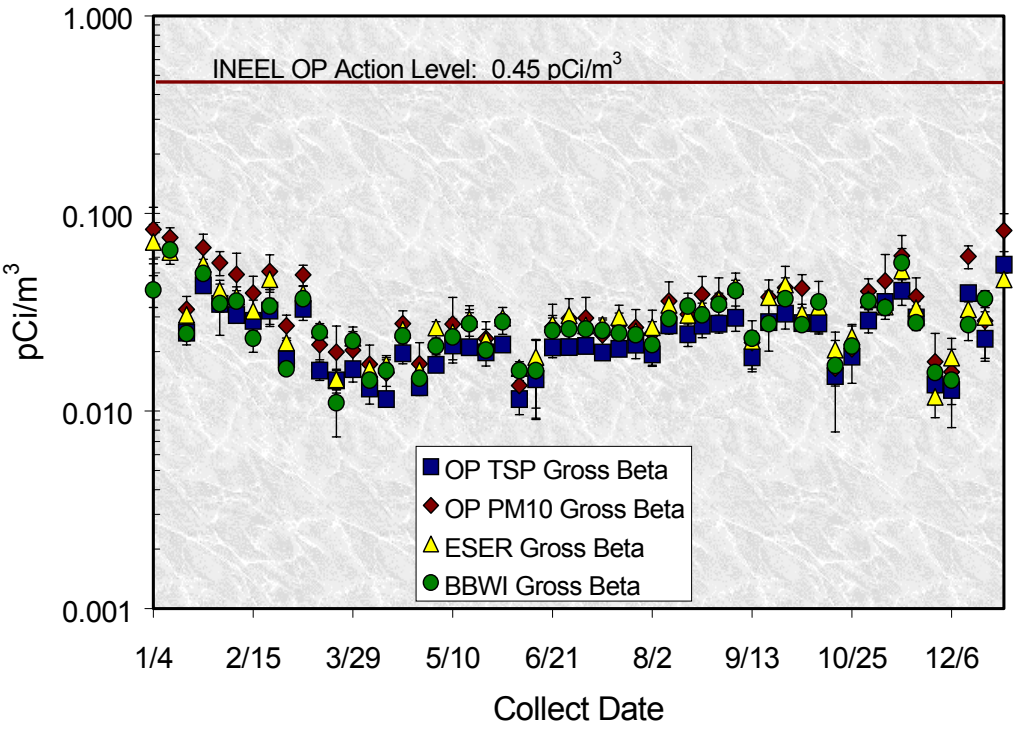


Figure 3-6. Average weekly gross beta screening results from co-located air samplers operated by INEEL OP, ESER, and BBWI during 2001. Gross beta activity concentrations are plotted on a logarithmic scale to demonstrate temporal variation. All gross beta screening results significantly below the INEEL OP Action Level corresponding to 1 mrem (10 μSv) per year assuming all of the beta activity is attributable to Sr-90 and remains constant.

Gross alpha and gross beta activity measurements reported by each monitoring program are assumed to be randomly collected from the same data set (statistical population), which is not necessarily normally distributed. Quantile-Quantile plots are used to provide a qualitative comparison between analysis results observed by the different monitoring programs. If the data from each sampling program are collected from the same sample population, the resultant plot should show a linear relationship with a slope of 1. Deviations from a linear correlation indicate that the data are not collected from the same population. A slope other than 1.0 indicates a sampling bias in the sample data collected from the population set. In cases where there is enough activity to measure precisely, direct comparisons of analyses are shown (**Figures 3-7** to **3-15**).

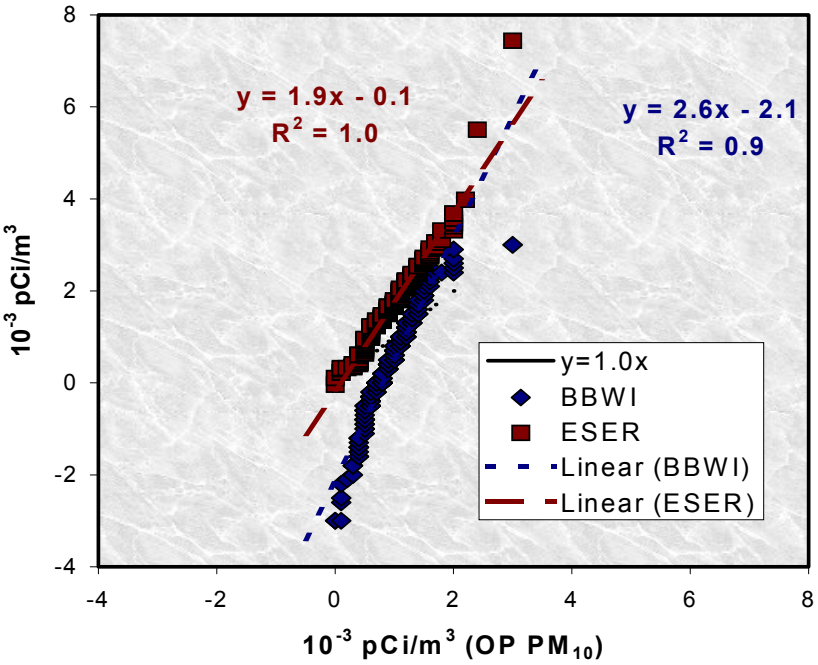


Figure 3-7. Quantile-Quantile plot comparing INEEL OP gross alpha screening measurements (using PM_{10} particulate samplers) with ESER and BBWI screening measurements. The solid black line represents an ideal "fit" where y = 1.0x.

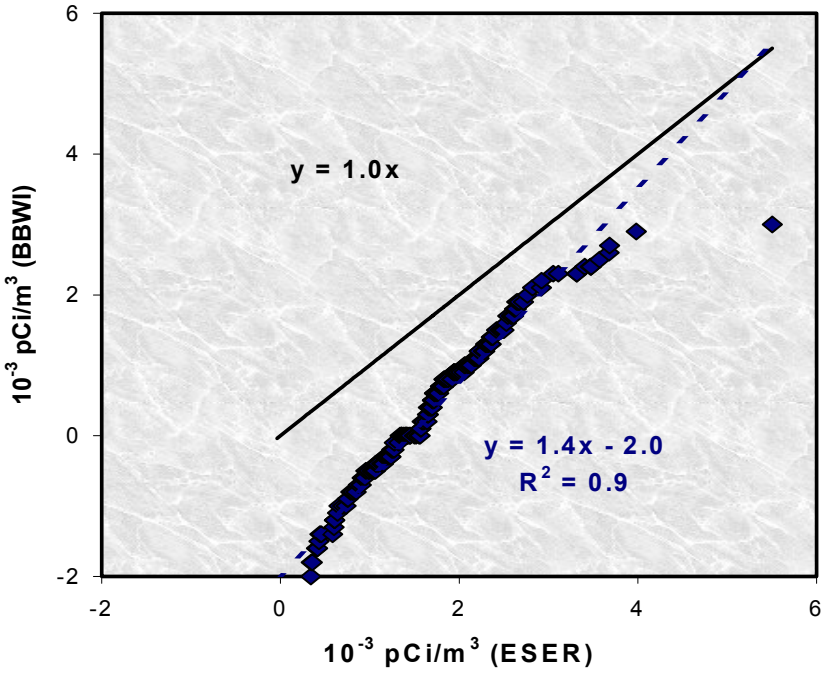


Figure 3-8. Quantile-Quantile plot comparing ESER and BBWI gross alpha screening results. The solid black line represents an ideal "fit" where y = 1.0x.

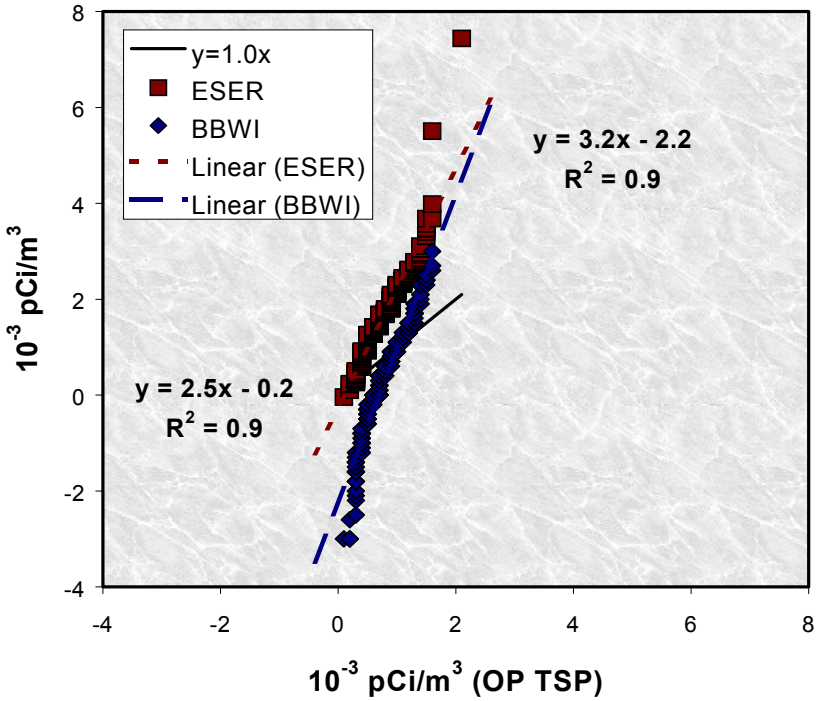


Figure 3-9. Quantile-Quantile plot comparing INEEL OP gross alpha screening measurements (using TSP samplers) with ESER and BBWI measurements. The solid black line represents an ideal "fit" where y = 1.0x.

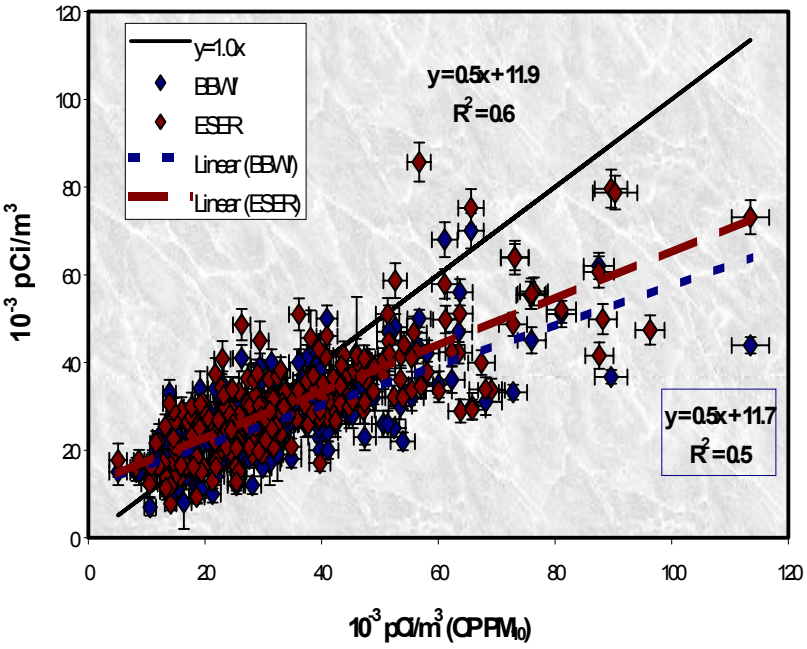


Figure 3-10. Comparison between INEEL OP gross beta screening measurements (using PM_{10} samplers) with gross beta screening measurements of filters collected by BBWI and ESER. The error bars represent the 2-sigma counting uncertainty and the solid black line represents an ideal "fit" where y = 1.0x.

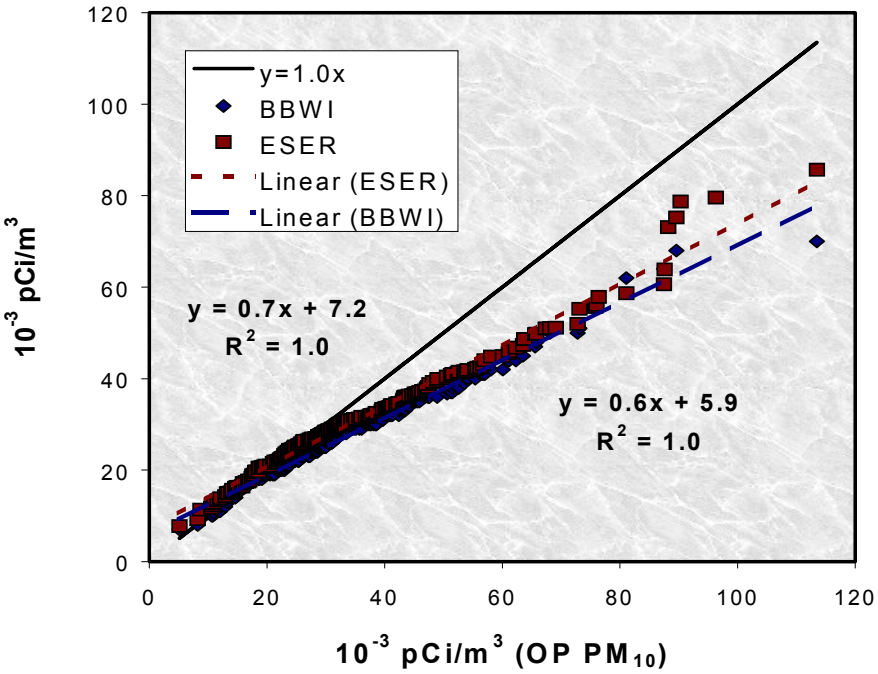


Figure 3-11. Quantile-Quantile plot comparing INEEL OP gross beta screening measurements (using PM_{10} samplers) with gross beta screening measurements of filters collected by BBWI and ESER using low-volume TSP samplers. The solid black line represents an ideal "fit" where y = 1.0x.

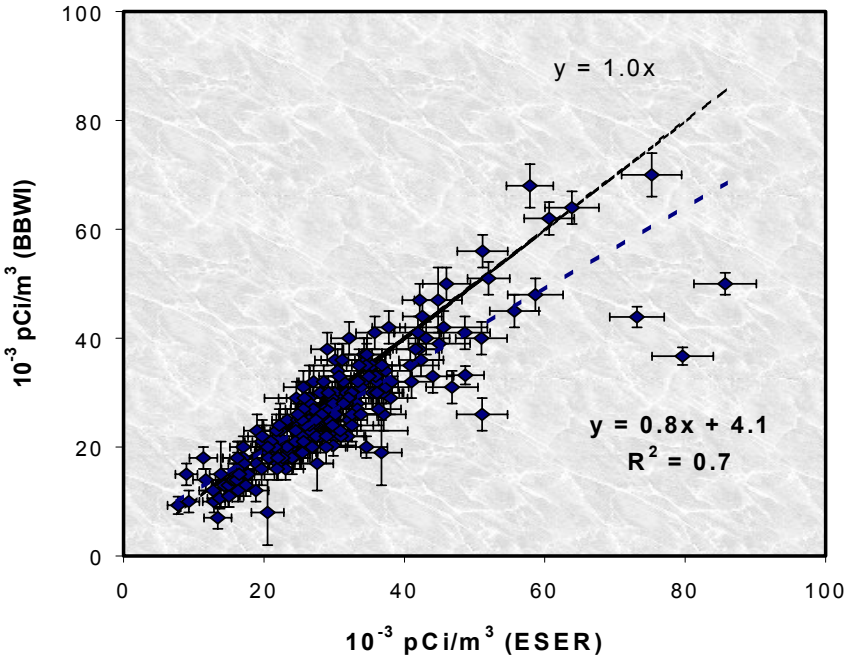


Figure 3-12. Direct comparison between ESER and BBWI gross beta measurements. The black line represents the ideal comparison between the two data sets. The error bars represent 2-sigma counting uncertainty and the dotted black line represents an ideal "fit" where y = 1.0x.

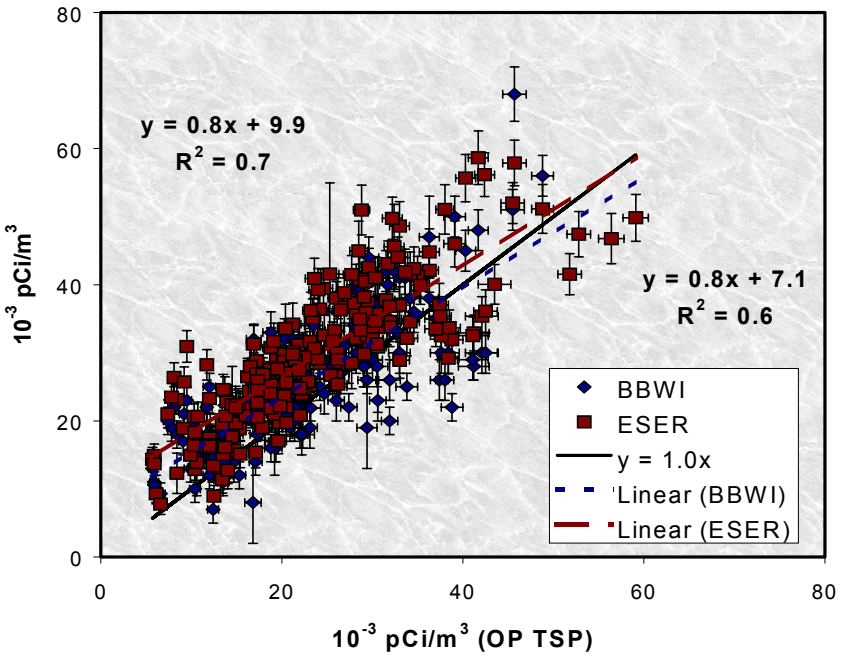


Figure 3-13. Quantile-Quantile plot comparing ESER and BBWI gross beta measurements. The solid black line represents the ideal comparison between the two data sets. The solid black line represents an ideal "fit" where y = 1.0x.

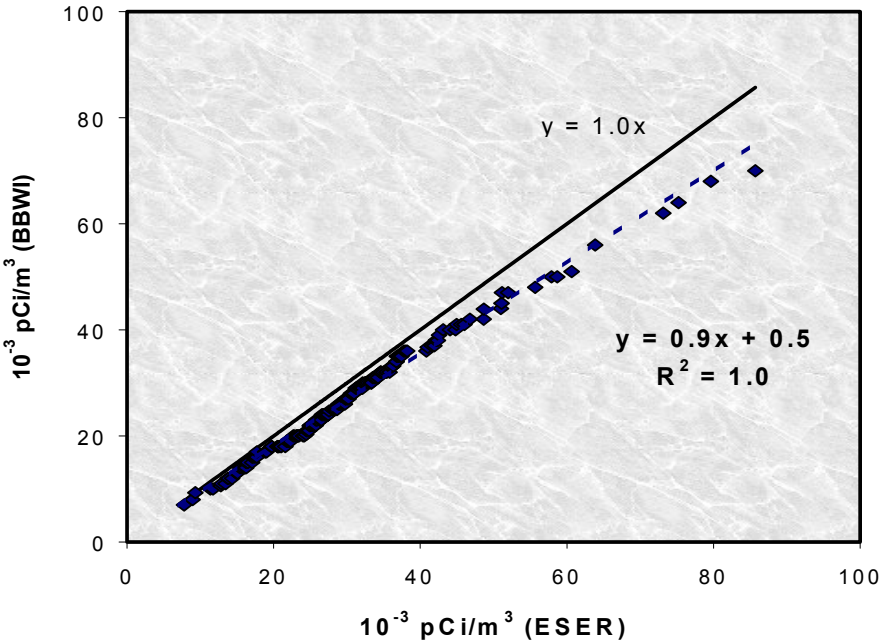


Figure 3-14. Comparison between INEEL OP gross beta screening measurements (using TSP samplers) with gross beta screening measurements of filters collected by BBWI and ESER using low-volume TSP samplers. The error bars represent 2-sigma counting uncertainty and the solid black line represents an ideal "fit" where y = 1.0x.

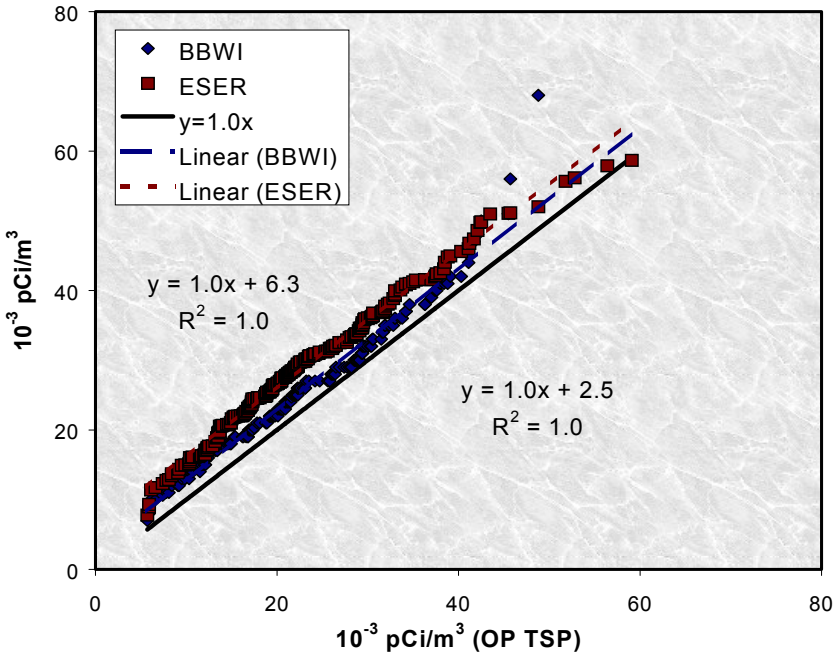


Figure 3-15. Quantile-Quantile plot comparing INEEL OP gross beta screening measurements observed on filters collected using PM_{10} samplers with gross beta screening measurements of filters collected by BBWI and ESER using low-volume TSP samplers. The solid black line represents an ideal "fit" where y = 1.0x.

Environmental Tritium Comparison

Several differences exist as to how BBWI, ESER, and INEEL OP monitor atmospheric tritium. These differences include sampling schedules, adsorbents used for collecting atmospheric moisture, and laboratory detection capabilities. Direct comparisons were not made due to significant differences in sampling schedules and resultant number of samples collected by the different monitoring organizations. The comparison between INEEL OP and ESER involved tritium concentrations in atmospheric moisture samples collected at Atomic City and Idaho Falls as well as for precipitation samples collected in Idaho Falls. Descriptive statistics are shown in **Table 3-5** for tritium concentrations in atmospheric moisture reported by ESER, tritium concentrations in precipitation samples reported by ESER, and atmospheric tritium concentrations reported by BBWI.

The likely causes for the discrepancies between INEEL OP, ESER, and BBWI measurements are due to differences in how BBWI, ESER, and INEEL OP monitor tritium in the environment. INEEL OP and ESER tritium concentrations in atmospheric moisture collected at Atomic City and Idaho Falls monitoring stations were compared (**Figure 3-16**). Tritium concentrations in water vapor did not compare well; similar to comparisons performed in past years. This may be due, in part, to low levels of tritium contamination experienced at ISU EML and ISU EAL, differences in background samples used, and detection capabilities.

INEEL OP and BBWI atmospheric tritium concentrations (pCi/m^3) were compared for Craters of the Moon National Monument, Experimental Field Station, Van Buren Avenue, and Idaho Falls. Descriptive statistics are also shown in **Table 3-5** and **Figure 3-17**. Atmospheric tritium concentrations did not compare as well as observed in past years. This may be due, in part, to low levels of tritium contamination experienced at ISU EML or differences in background water samples used by the different laboratories. Observed tritium concentrations were well below the INEEL OP action level of 790 pCi/m^3.

Table 3-5. Atmospheric tritium measurements performed by INEEL OP, ESER, and BBWI at co-located monitoring sites

	Tritium		
	OP	**ESER**	**BBWI**
Atmospheric Moisture (nCi/L)			
Average:	0.02	0.17	
Median:	0.02	0.17	
Standard Deviation:	0.05	0.14	
Minimum:	-0.07	-0.19	
Maximum:	0.13	0.44	
Number of Samples:	22	36	
Precipitation (nCi/L)			
Average:	0.008	0.046	
Median:	-0.005	0.072	
Standard Deviation:	0.045	0.094	
Minimum:	-0.030	-0.196	
Maximum:	0.070	0.125	
Number of Samples:	4	11	
Atmospheric (pCi/m^3)			
Average:	0.38		0.36
Median:	0.25		0.28
Standard Deviation:	0.45		0.61
Minimum:	-0.30		-0.50
Maximum:	1.65		1.63
Number of Samples:	40		28

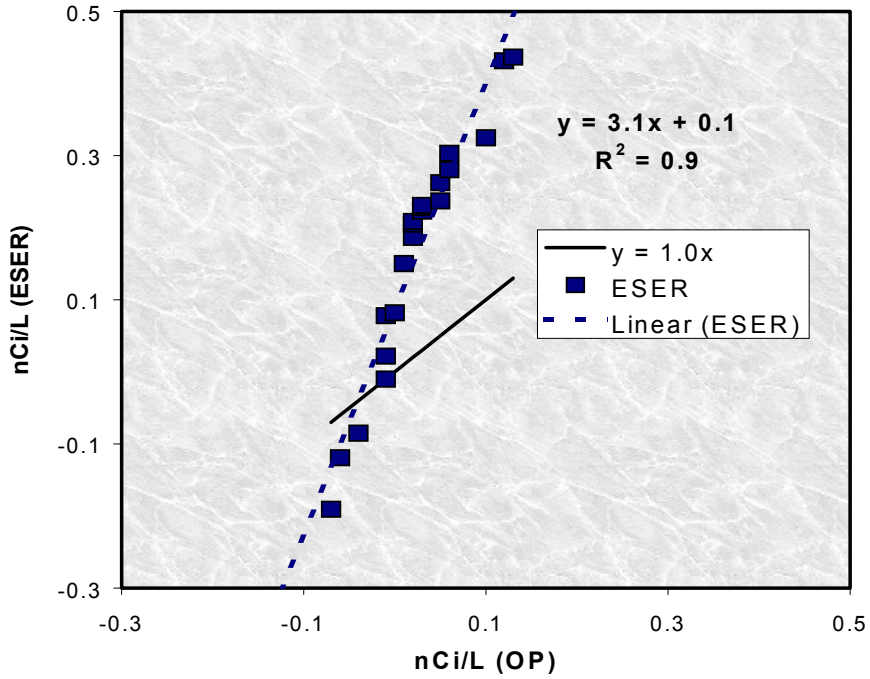
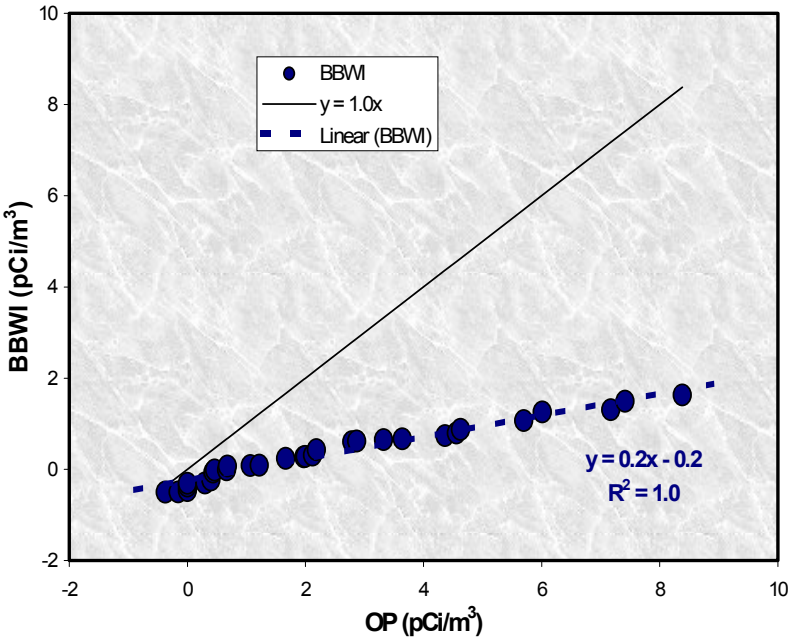


Figure 3–16. Quantile-Quantile plot comparing tritium concentrations in atmospheric moisture samples collected at Atomic City and Idaho Falls by ESER and INEEL OP.

Figure 3-17. Quantile-Quantile plot comparing atmospheric tritium concentrations measured by INEEL



OP and BBWI at Craters of the Moon National Monument, Experimental Field Station, Van Buren Avenue, and Idaho Falls during the 2001 calendar year.

References:

National Council on Radiation Protection and Measurements, Exposure of the Population in the United States and Canada from Natural Background Radiation, NCRP Report Number 94, 1987.

National Council on Radiation Protection and Measurements, Measurement of Radon and Radon Daughters in Air, NCRP Report Number 97, 1988.

US EPA, EPA 402-B-92-001, Clean Air Act Assessment Package – 1988 (CAP88PC) computer code, Version 1.0, March 1992.

Chapter 4
Terrestrial Monitoring

Major Findings and Developments

Gamma spectroscopic analysis of soil samples and milk samples collected during 2001 were consistent with historical concentrations. INEEL OP observed no man-made radionuclides in milk samples collected during 2001, specifically iodine-131. Cesium-137 concentrations observed in soil samples collected during 2001 were consistent with historical measurements onsite and within expected background concentrations offsite attributable to historical atmospheric nuclear weapons testing**.**

- No offsite environmental impacts resulting from INEEL operations were indicated as a result of the analyses of milk or soil samples.
- Comparisons of gamma spectroscopic analysis of milk samples collected by DOE-ID contractor and INEEL OP indicated slight, yet expected, discrepancies in potassium-40 concentrations likely due to differences in analytical techniques employed by the respective laboratories.

Primary Terrestrial Results and Trends

Terrestrial samples collected during 2001 indicated no concentrations of radionuclides attributable to INEEL operations above levels considered to pose a health risk. Terrestrial monitoring involves collecting milk samples from distribution centers and *in-situ* gamma spectroscopic analysis at various soil sampling locations. Milk and soil samples are analyzed specifically to identify man-made radionuclides.

Milk Sampling

Milk samples are collected monthly from milk distributors and are analyzed at the ISU EML for iodine-131, using gamma spectroscopy techniques**.** **Figure 4-1** shows the reported concentrations of iodine-131 in milk samples collected by INEEL OP. INEEL OP has not observed iodine-131 concentrations greater than the MDC of 4 pCi/L since the inception of milk sampling program in 1996.

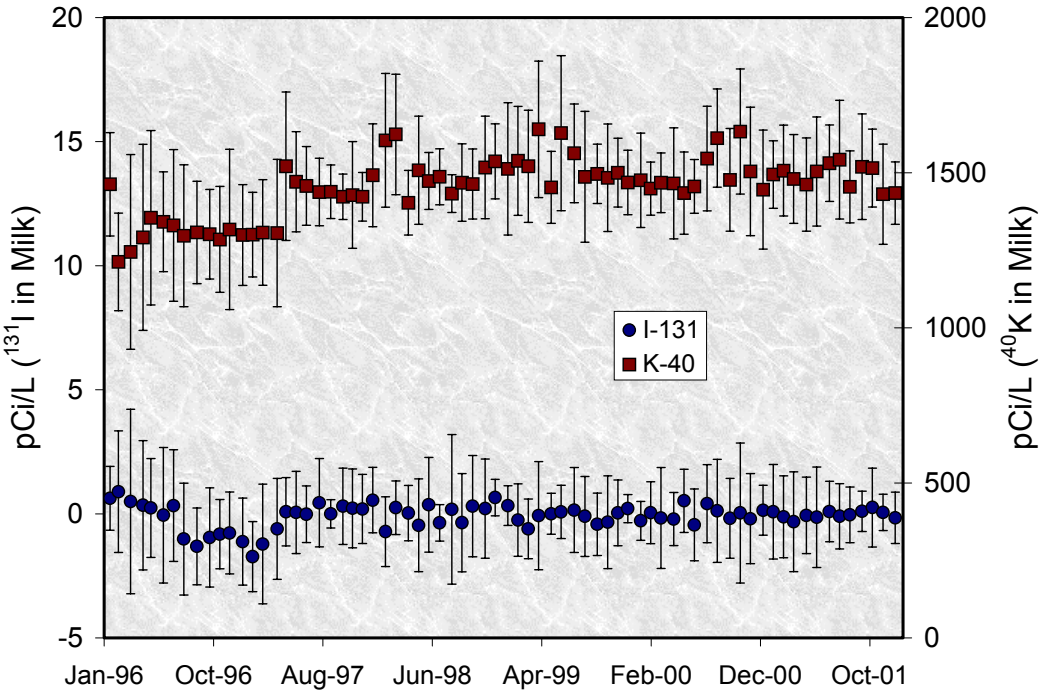


Figure 4-1. Average concentrations of iodine-131 and potassium-40 in milk samples collected monthly by INEEL OP since January 1996. Milk samples are collected from milk distributors located in Rupert, Rexburg, Pocatello, Gooding, and Blackfoot.

Soil Sampling

Concentrations of cesium-137 and potassium-40 were measured using *in-situ* gamma spectroscopic analysis techniques at 44 locations. These measurements were made on the INEEL as well as at boundary and distant locations. Potassium-40 is ubiquitous in nature. Its characteristic 1460 keV gamma emission provides a quality assurance measurement during *in-situ* monitoring of gamma emitting radionuclides distributed in soil. Descriptive statistics for INEEL OP *in-situ* gamma-spectroscopic soil measurements are shown in **Table 4-1**.

Table 4-1. Descriptive statistics of *in-situ* gamma spectroscopic analyses conducted by INEEL OP during 2001. Results for cesium-137 and potassium-40 are shown

	Cesium-137 (pCi/g)	Potassium-40 (pCi/g)
Average Value:	2.0	13.5
Median Value:	0.5	14.1
Standard Deviation:	3.5	2.4
Minimum Value:	0.1	7.3
Maximum Value:	13.6	17.2

In-situ gamma spectrometry was conducted in lieu of collecting soil samples. Rather than physically collecting a sample, which disturbs the soil and prevents the collection of a sample at the exact location, the concentration of radionuclides in the soil can be measured *in-situ* (i.e., directly in the field). Radionuclide concentrations were determined using an intrinsic, high-purity germanium detector assuming the distribution of radionuclides in the soil was homogenous throughout a soil depth of 0 to 5 cm. *In-situ* soil gamma spectrometry results from each location are shown in table 4-2.

Table 4–2. *In-situ* soil measurement locations near INEEL OP air and radiation monitoring stations and near INEEL facilities onsite

	Cesium-137 (pCi/g)	Potassium-40 (pCi/g)
Distant Location		
Idaho Falls	0.1 ± 0.0 [a]	7.9 ± 0.4
Boundary Locations		
Big Southern Butte	0.4 ± 0.0	12.4 ± 0.6
Mud Lake	0.1 ± 0.0	14.8 ± 0.5
Monteview	0.2 ± 0.0	12.1 ± 0.5
Reno Ranch	0.6 ± 0.0	10.9 ± 0.5
Onsite Locations		
Base of Howe Peak	0.3 ± 0.1	12.6 ± 0.7
INTEC (soil location #02)	13.6 ± 0.2	15.7 ± 0.8
INTEC (soil location #05)	9.3 ± 0.2	15.2 ± 0.8
Naval Reactors Facility (01)	0.6 ± 0.1	13.8 ± 0.7
Naval Reactors Facility (02)	0.5 ± 0.1	15.9 ± 0.8
Power Burst Facility (02)	0.5 ± 0.1	12.2 ± 0.7
Power Burst Facility (03)	0.5 ± 0.1	14.1 ± 0.7
Power Burst Facility (04)	0.5 ± 0.1	16.3 ± 0.8
Test Area North	0.3 ± 0.1	14.8 ± 0.8
Test Reactor Area (2.0)	1.3 ± 0.1	15.3 ± 0.8
Test Reactor Area (2.3)	1.3 ± 0.1	15.4 ± 0.8
Test Reactor Area (3.3)	11.4 ± 0.2	14.1 ± 0.7
Test Reactor Area (3.4)	0.8 ± 0.1	15.8 ± 0.8

[a] Corresponds to the 2-sigma counting uncertainty.

Interprogram Comparisons of Terrestrial Monitoring Results

Milk Sampling

Beginning in April 2001, ESER submitted two milk samples per month to INEEL OP for verification analysis. In essence, this split sample provides a co-sampling opportunity for milk

sampling. Both INEEL OP and ESER perform gamma spectroscopic analyses of milk samples collected from dairies near the INEEL and from dairies located at distant locations with respect to INEEL. Neither INEEL OP nor ESER observed iodine-131 in milk samples routinely collected in 2001.

Direct comparison of samples ESER submitted to INEEL OP demonstrated relatively good agreement. The 16 milk samples analyzed for iodine-131 were within 3-sigma agreement and each measurement was less than the laboratories' MDC. Assuming the simulated potassium-40 background used by the ESER laboratory subtracts 1-nCi/L of potassium-40 from the sample, 75% of the potassium-40 analysis results of the 16 milk samples were within 3-sigma agreement. The average relative difference between INEEL OP and ESER potassium-40 concentrations, with respect to INEEL OP measurements, was 3.5% (assuming the 1.0-nCi/L bias from the simulated potassium-40 background).

The quantile-quantile plots shown in **Figure 4-2** and **Figure 4-3** demonstrate the agreement between INEEL OP and ESER for iodine-131 and potassium-40 concentrations. The good correlation coefficient (R^2 approaching 1) indicates that the samples were collected from the same sample population. The slope indicates a possible bias possibly due to the different background subtraction algorithms used by the different laboratories, slight variations in detector efficiency, and/or slight differences in detection capabilities.

Soil Sampling

During 2001, the INEEL OP did not co-sample soil with ESER.

INEEL OP conducted seven *in-situ* gamma spectrometry measurements in 2001 for comparison with BBWI. Descriptive statistics comparing these measurements are provided in **Table 4-3**. Potassium-40 measurements agreed well between BBWI and INEEL OP and cesium-137 measurements agreed moderately well.

To determine data correlation between programs, INEEL OP examines the relative difference between one measurement and the mean of both programs' measurements. If the absolute value of the relative difference is less than 20% or the two reported values are within 3-standard deviations of the reported uncertainty, the results are considered to be in agreement. Agreement is considered "good" if at least 80% of the paired samples meet these criteria. Differences may be due to slight variations in detection efficiency and distribution of cesium-137 in the environment. These differences are extremely subtle as shown in **Figure 4-4**. The slope of the trend line is 1.0 with a very strong correlation coefficient ($R^2 = 0.99$).

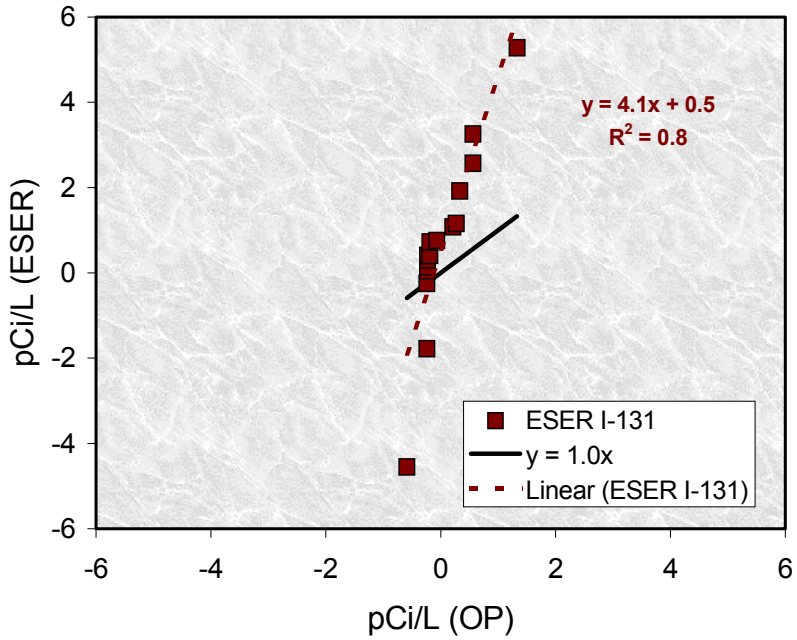


Figure 4-2. Quantile-Quantile plot comparing I-131 concentrations observed in split samples collected by ESER and reported by INEEL OP and ESER.

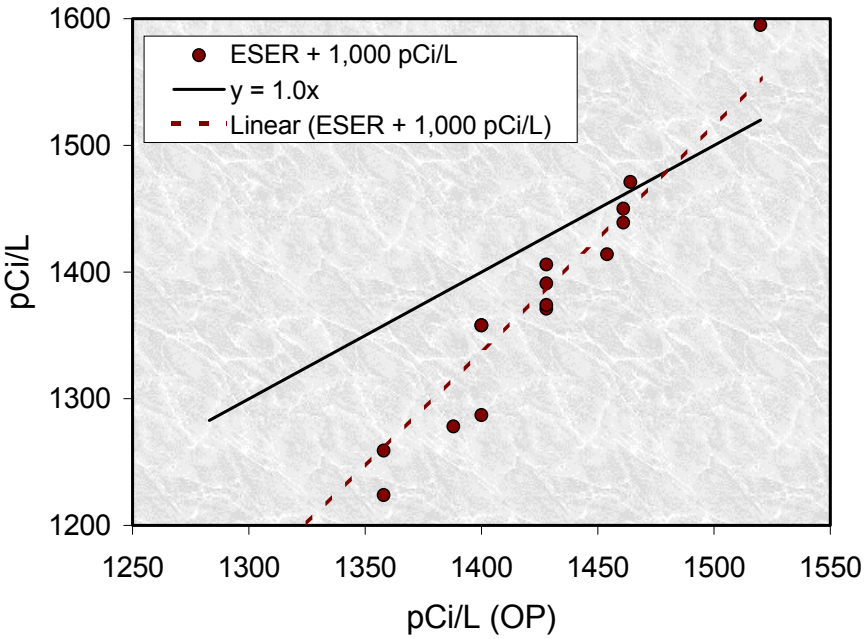


Figure 4-3. Quantile-Quantile plot comparing K-40 concentrations observed in split milk samples collected by ESER and reported by INEEL OP and ESER. ESER measurements are corrected for the 1 nCi/L simulated K-40 background used by the laboratory performing analyses for ESER.

Table 4-3. Descriptive statistics for co-located *in-situ* measurements performed by INEEL OP and BBWI in 2001. Cesium-137 and potassium-40 results shown

	Cesium-137 (pCi/g)		Potassium-40 (pCi/g)	
	OP	**BBWI**	**OP**	**BBWI**
Average:	7.4	7.9	15.1	15.2
Median:	7.9	8.7	15.1	15.1
Standard Deviation:	3.6	3.6	0.3	0.6
Minimum Value:	3.2	3.9	14.9	14.6
Maximum Value:	13.6[a]	14.4	15.7	15.9

[a] The maximum value was observed at an onsite location near INTEC.

	Cesium-137	Potassium-40
Average Relative Difference:	10.0%	0.5%
Number of Measurements Compared:	7	7
Percent Agreement (3-sigma):	28.6%	100%
Percent Agreement (Relative Difference):	85.7%	100%

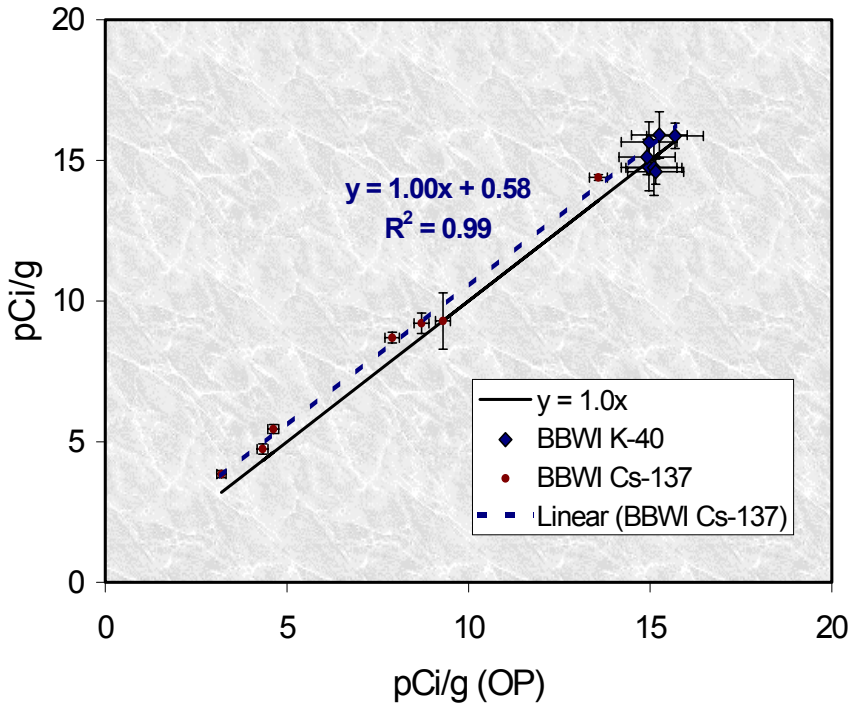


Figure 4-4. Direct comparison of BBWI *in-situ* gamma spectrometry results for Cs-137 and K-40 at co-located monitoring locations with INEEL OP. Linear regression indicates good agreement between the seven measurements as shown by the slope of 1.00 and correlation coefficient (R^2 = 0.99).

Chapter 5
Water Monitoring

Major Findings and Developments:

Tritium, gross beta radioactivity, strontium-90, and chromium exceeded drinking water standards in the Eastern Snake River Plain Aquifer beneath several facilities at the INEEL. Contaminant concentrations generally decreased or remained constant through 2001, based on samples from INEEL OP water surveillance locations.

- Drinking water standards were not exceeded at any sites where water is used by the public or INEEL workers.
- No contamination attributable to the INEEL was identified in samples collected at distant or Magic Valley monitoring sites, however, INEEL impacts can be identified at some sites along the southern boundary of the INEEL. Tritium concentrations at these sites were greater than background but less than 1% of drinking water standard. Chromium at these wells also exceeded background but was less than 5% of the drinking water standard.
- Analytical results from INEEL OP monitoring were generally in close agreement with results reported by the USGS and ESER.
- The USGS reduced sampling frequency for onsite and boundary locations beginning with the fourth calendar quarter 2001.

Primary Nonradiological Results and Trends

Water samples collected by the INEEL OP in 2001 from distant or Magic Valley locations did not exhibit concentrations of nonradiological contaminants indicative of impacts from the INEEL. Similarly, the majority of analyses on samples collected from boundary wells detected only concentrations reflecting background or non-INEEL anthropogenic influences. However, common ions, nutrients, or trace metals attributable to INEEL impacts were detected in some boundary wells, as well as in several onsite wells. **Table 5-1** compares the minimum and maximum concentrations of nonradiological constituents to their respective background estimations and any applicable drinking water standards.

INEEL OP detected calcium, sodium, potassium, chloride, sulfate, nitrate plus nitrite, total phosphorous, barium, chromium, zinc, gross beta radioactivity, and tritium above background concentrations at some sites on the INEEL. Additionally, strontium-90 and technetium-99, which are beta-emitting radionuclides that were historically disposed of to the aquifer at the INEEL, were detectable in samples from at least two INEEL OP on-site locations. A brief summary of these analytes is presented here. A more complete discussion of surveillance monitoring results for 2001 and historic trends for selected nonradiological and radiological analytes is presented in "Environmental Surveillance Program Water Quality Trends for Surveillance Monitoring Sites, 1994 - 2001 Data" (Hall, 2003b).

Table 5-1. Summary of selected nonradiological INEEL OP water surveillance analytical results, 2001

Analyte	Range of Concentrations					Background[a] Concentrations for the Snake River Plain Aquifer	Drinking Water Standard
	Sites on the INEEL			Boundary, Distant and Surface water sites			
	Min	Max	Median	Min	Max	Median	
Common Ions/Nutrients (mg/L)							
Calcium	30.4 – 87.5		44.9	9.2 – 57.3	38.3	5 – 43	None[b]
Magnesium	12.3 – 27.1		16.9	2.8 – 20.4	15.2	1 – 15	None
Sodium	8.2 - 54		15	5.2 – 35	14	5 – 14	None
Potassium	1.3 – 5.9		3.2	0.9 – 6.2	2.7	1 – 3	None
Chloride	8.2 - 125		20.4	3.9 – 39.6	14.2	2 – 16	SMCL[d]=250
Sulfate	19.4 - 161		28.2	8.1 – 56.4	22.3	2 – 24	SMCL=250
Total Nitrate plus Nitrite (as nitrogen)	0.578 – 3.94		1.315	0.045 – 2.01	0.84	1-2	MCL=10
Total Phosphorus	0.005 – 0.026		0.015	0.009 – 0.038	0.014	<0.02	None
Trace Metals (µg/L)							
Barium	29 - 182		58	18 – 76	33	50 – 70	MCL=2000
Chromium	4 - 142		9	2 – 7	4	2 – 3	MCL=100
Zinc	2- 620		45	2 – 336	61	<10	SMCL=5000
Manganese	<1 - 3		1.5	<1	<1	<1 - 4	None
Lead	<5 – 13		<5	<5	<5	<5	AL[e] = 15

a. Background is defined as ambient conditions for sites with no obviously anthropogenic influence. The range given is from Knobel and others (1992), or defined by the minimum and median from Knobel and others (1999).
b. Not applicable, no standard set.
c. Maximum Contaminant Level
d. Secondary Maximum Contaminant Level
e. Action Level

A significant development during 2001 was the reduction in sample frequency by the USGS, and a corresponding reduction in sampling frequency for INEEL OP. In response to budgetary pressures and following a review of monitoring data, the USGS enacted a new sampling schedule during the fall of 2001. All sites sampled quarterly by the USGS prior to September 2001 were reduced to semiannual sampling (CFA 1, CFA 2, RWMC Production, USGS 65, 87, 112, 115, and 120). Sites sampled semiannually that are not significantly impacted by the INEEL were reduced to sampling once a year. Annual sites cosampled by INEEL OP are Atomic City, P&W 2, Site-14, USGS 8, 19, 27, and USGS 100. Semiannual sites indicating more INEEL impacts (USGS 11, 14, 85, 108, 124 and 125) remained on a twice-a-year schedule. INEEL OP monitoring changed accordingly with the exception that Atomic City, now sampled once a year by the USGS, will continue to be monitored quarterly by INEEL OP. Additionally, INEEL OP reduced sampling frequency for nonradiological parameters at Atomic City and Mud Lake water supply from quarterly to once a year, corresponding to the USGS sampling at these sites (during the third calendar quarter). INEEL OP continues to sample Atomic City and Mud Lake water supply for gross radioactivity and tritium each quarter.

A synopsis of the water surveillance sampling locations, schedules, analyses, and procedures specific to the INEEL OP water monitoring strategy appears in **Chapter 2.**

Common Ions and Nutrients

Calcium, magnesium, sodium, potassium, chloride, sulfate, total nitrate plus nitrite as nitrogen, and total phosphorus were detected in some groundwater samples collected on the INEEL at concentrations believed to represent contamination from activities on the site. These ions, along with a form of carbonate ions, constitute a majority of the dissolved components of natural ground waters ("major ions"), and can vary due to differences in geology of the aquifer recharge areas (Hall, 2000). Concentrations of these ions can also vary due to anthropogenic influences such as evaporation of infiltrating irrigation water or injection or infiltration of wastewaters. Water quality trends for 2001 monitoring and results are given in Hall (2003b).

Calcium

Calcium concentrations at several onsite wells (CFA 1, CFA 2, USGS 65, USGS 85, and USGS 112) exceeded expected background range for the aquifer estimated from data published by Knobel and others (1992). The highest concentrations are observed in samples from USGS 65 (see **Table 5.1** for range of concentrations observed for onsite, boundary, and distant locations). Calcium is not identified as a major component of INEEL wastewater. However, the elevated concentration and similarity in historical trends of calcium and some other major ions in ground water (magnesium, potassium, sodium and chloride) to major waste components which include chloride, sulfate, and sodium suggest that the elevated calcium values observed are disposal related for the identified onsite wells. Calcium concentrations for wells CFA 1 and CFA 2, as well as the observed relationship between the major ions listed, could result from concentration of natural levels of calcium through evaporation of wastewaters allowed to infiltrate to the aquifer. Levels for these constituents do not exceed risk-based limits, but are elevated compared with concentrations at the upgradient water surveillance monitoring sites.

Calcium concentrations in samples collected at Alpheus Spring, a distant location, exceeded the expected background. Concentrations of other analytes are slightly elevated at this site indicating possible anthropogenic influences.

For the April 2001 sample from upgradient well P&W 2, concentrations for calcium, as well as magnesium, chloride, nitrate plus nitrite, sulfate, and barium increased significantly as compared with historical results. Calcium and other analytes increased by 50% in this well for that sample while chloride increased by a factor of 10. Other trace elements and radiological parameters did not change. USGS monitoring results and conductivity measured in the field confirmed a significant change in groundwater constituents. Due to a change in sampling schedule, P&W 2 was not scheduled to be sampled again until July 2002. To follow up on the 2001 results, the well was sampled in April 2002, with preliminary results returning to pre-2001 historical trends. No quality assurance problems were identified with the April 2001 results and no other explanations can be found. This well was used as a source of water for nearby USGS well drilling activities, which could be a factor. Further discussion is presented in Hall (2002a).

Magnesium

Magnesium concentrations in samples from onsite wells exceed the expected background range for onsite wells CFA 1, CFA 2, USGS 65, and USGS 112, with CFA 2 having the highest concentrations. Magnesium and calcium results follow similar trends for CFA 1 and CFA 2, and for USGS 65 and USGS 112. Magnesium, as with other major ions, is a natural constituent of groundwater beneath the INEEL that is not identified as an INEEL waste constituent. Trends for the elevated concentrations of magnesium reflect those observed for other major ions and are likely reflective of INEEL waste disposal. See the discussion for calcium for more details.

Magnesium concentrations observed for samples from some boundary and distant wells generally were within the estimated background range. Average concentrations of magnesium in samples from the Mud Lake water supply were significantly lower than all other sites due to natural variability within the Snake River Plain Aquifer.

The magnesium concentration for P&W 2 was approximately 50% greater than historical trends for that site. See the discussion for calcium for more details.

Sodium

Sodium is identified as a major waste constituent for INEEL facilities. Concentrations for wells CFA 1, CFA 2, USGS 85, and USGS 112 reflect that waste disposal influence: The highest concentrations are observed in well USGS 112, with historic trends similar to chloride and to most other major ions for CFA 1 and CFA 2. In general, the boundary, distant, and surface water samples yielded sodium concentrations within background levels. Concentrations for the Mud Lake water supply exceed the published background range, due to natural aquifer variability. Elevated concentrations for USGS 27 and Alpheus Spring might be reflective of either natural variability or anthropogenic influences.

Potassium

A drinking water standard has not been established for potassium. Concentrations of dissolved potassium in groundwater samples are typically less than 4 mg/L. These concentrations vary as a result of natural variability, waste disposal at the INEEL, or other anthropogenic influences.

Potassium concentrations from onsite wells USGS 112, CFA 1, and CFA 2 are not significantly greater than the expected background levels, but some of the potassium present is due to past disposal activities at INTEC. See the discussion for calcium. The highest potassium concentrations observed were for samples from upgradient well USGS 27 inside the INEEL boundary near Mud Lake.

The potassium concentration was highest at Alpheus Spring for boundary, distant, and surface water sites. The Mud Lake water supply well, near USGS 27, had potassium concentrations slightly above the background range with no indication of anthropogenic influences. Potassium concentrations observed for USGS 27 may represent anthropogenic influences.

Chloride

The secondary maximum contaminant level (SMCL) for chloride, historically a major constituent of INEEL chemical wastes, is 250 mg/L.. Elevated chloride may also indicate surface water, irrigation, or other anthropogenic impacts (Hem, 1985).

Chloride concentrations for onsite wells USGS 112, 115, 85, CFA 1, and CFA 2 exceeded the background range, with the highest values found in samples from USGS 112. Since 1997, chloride concentrations for USGS 112 have declined about 30 percent. Chloride levels for the onsite locations listed, as well as USGS 85, are likely impacted by INEEL waste disposal.

Alpheus Springs, Clear Springs, and the Minidoka water supply exceeded the background range for chloride. Other constituents (sodium, nitrate plus nitrite as nitrogen) suggest that Alpheus and Clear Springs have some degree of impact due to anthropogenic sources not associated with the INEEL. This is supported by tritium levels, which reflect levels observed in surface water for other INEEL OP monitoring. Minidoka water supply chloride concentrations are likely due to natural sources with no indication of impact from INEEL activities or other anthropogenic sources.

The chloride concentration for P&W 2 in 2001 was nearly a factor of ten greater than historical trends. See the discussion for calcium for more details.

Sulfate

No wells sampled exceeded the SMCL of 250 mg/L for sulfate, historically a major INEEL waste constituent. Elevated sulfate can also be an indication of impacts from surface water, irrigation, or other anthropogenic impacts.

Sulfate concentrations were highest in samples collected from USGS 65, where water quality has been impacted by waste disposal at TRA. Concentrations from samples for wells USGS 112, 85, 87, 120, 104, CFA 1, CFA 2, and RWMC Production all exceeded the background range for sulfate with trends for sulfate similar to calcium and magnesium. Concentrations for these wells are likely due to INEEL waste disposal.

Alpheus Springs, and Clear Springs sulfate concentrations were highest for boundary, distant, and surface water samples. These sulfate results along with chloride concentrations are attributable to a combination of local anthropogenic influences.

Sulfate concentration for P&W 2 in 2001 was approximately twice historical values. See the discussion for Calcium for more details.

Nitrate Plus Nitrite As Nitrogen

The MCL for nitrate plus nitrite (as nitrogen) is 10 mg/L with concentrations greater than 1-2 mg/L indicating anthropogenic impacts to groundwater of the Eastern Snake River Plain Aquifer (Rupert, 1994, 1997).

Nitrogen concentrations are elevated for seven onsite locations, and greatest for wells CFA 1, CFA 2, and USGS 112. Elevated concentrations at these and other sites (USGS 65, 85, 115, and 100) are the result of past wastewater disposal at INTEC and TRA. The highest concentration detected in groundwater is from well CFA 2. The upgradient site USGS 27 likely shows agricultural impacts.

Concentrations for boundary, distant, and surface water sites were all within the 1-2 mg/L background range. Alpheus Springs, already discussed as having concentrations of other constituents indicative of anthropogenic impacts, was near the upper background range.

Nitrate plus nitrite concentration for P&W 2 was approximately twice historical values. See the discussion for calcium for more details.

Total Phosphorus as P

Total phosphorous as P exceeded the background levels in two wells, USGS 112 and USGS 85. The median result for sample sites on the INEEL was similar to distant, boundary and surface water sites.

The highest values were from a boundary location, the Mud Lake water supply. This higher concentration is indicative of local hydrogeologic conditions, as other indicators of anthropogenic influences are absent at this well (such as low nitrate plus nitrite and very low tritium).

Trace Metals

Groundwater samples collected by INEEL OP in 2001 were analyzed for barium, chromium, zinc, lead, and manganese. Chromium and barium can be directly linked to INEEL waste disposal activities. Concentrations of zinc, lead, and manganese may be related to well construction materials, natural concentrations, as well as anthropogenic INEEL sources.

Barium

In all 2001 water samples, barium concentrations were considerably lower than the MCL of 5000 μg/L. Barium was detected in all samples collected from INEEL sites, with the highest concentrations being reported for USGS 112. Barium was above background levels for CFA 1, CFA 2, and USGS 85. Barium has historically been a waste product from INTEC. Trends observed for CFA 1, CFA 2, and USGS 85 reflect those of other known INEEL waste constituents (e.g., sodium and chloride).

Barium concentrations for boundary, distant, and surface water sites were highest for samples collected from the Big Lost River and lowest for sites on the eastern side of the INEEL. The distribution for sites not influenced by the INEEL may provide information on recharge areas for groundwater.

Chromium

The primary source of chromium contamination at the INEEL is TRA, where it was used as a corrosion inhibitor until 1972. Lesser amounts of chromium, used for the same purpose, were disposed of at INTEC and other INEEL facilities (Frederick and others, 1998). Chromium concentrations for samples from USGS 65 located south of TRA exceeded the MCL of 100 μg/L.

Samples for other INEEL sites; RWMC Production, USGS 85, 87, CFA 1, CFA 2, and USGS 115 exceeded background. Other sites, USGS 104, 103, 108, 112, and 14 also show results greater than background. Monitoring results suggest the chromium background in the vicinity of the INEEL may be greater than the published range of 2-3 μg/L (Knobel and others, 1992). Chromium in excess of about 6-7 μg/L for samples from onsite locations down gradient from TRA-INTEC is likely due to historical waste disposal. Chromium concentrations for USGS 65 have decreased consistently, declining about 30% since 1994.

Chromium concentrations for boundary, distant, and surface water sites were less than 7 μg/L. All surface water and distant sites were at or less than the detection level. Concentrations for boundary sites USGS 14, 103, 104, 108, 124, and 125 may indicate INEEL impacts, contamination from well materials, or natural variations in background.

Zinc, Lead and Manganese

There does not appear to be a clear relationship between a disposal point, distribution within the aquifer, and historical contaminant trends for the remaining trace metals.

Zinc concentrations were less than the secondary MCL (5000 µg/L) with the highest zinc concentrations observed in samples from USGS 115 (470-615 µg/L). Other INEEL wells with elevated zinc include Highway 3, USGS 65, 103, 104, and 112. Wells with detectable zinc tend to have dedicated submersible pumps installed in them. Many of the sites that do not have detectable zinc or have very low zinc have turbine pumps or are surface water sites. Thus, some degree of zinc contamination may be related to the well construction and the type of pump installed in the well.

Historically, lead and manganese have been measured in some INEEL waste streams (Frederick and others, 1998) and detected in a limited number of INEEL monitoring wells. Lead was detected in samples from two wells on the INEEL, USGS 100 and 104 (12 µg/L and 5 µg/L). Manganese was detected at eight sites. Three of the sites are on the INEEL (CFA 2, USGS 85, and 87), and the remainder USGS 27, 103, 124 125, and Mud Lake water supply) are boundary or upgradient sample locations. Manganese concentrations ranged from the detection level of 1 µg/L to 5 µg/L onsite and 36 µg/L for the Mud Lake water supply. While both of these contaminants are or have been present in INEEL waste waters, concentrations are within that reported by others for the Eastern Snake River Plain Aquifer (Wood and Low, 1988) and are likely due to natural variability or anthropogenic influences at the well, such as well construction materials or foreign materials known to be present in the well (Hall, 2003a).

Primary Radiological Results and Trends

Water samples were collected by the INEEL OP and analyzed for gross alpha and gross beta radioactivity, gamma-emitting radionuclides, and tritium. Samples from selected sites were also collected and analyzed for strontium-90 and technetium-99. **Table 5-2** summarizes INEEL OP's radiological results for water sampling.

Gross Radioactivity

Water samples collected from all sample sites are analyzed for gross alpha and gross beta activity. Gross measurements are primarily a screening tool used to identify whether or not more specific analyses are needed. As samples for these gross measurements are collected at all monitoring sites, they provide a means of overall variability. Where these gross measures exceed expected ranges, or historical sampling has indicated the presence of alpha- or beta-emitting radionuclides, radiochemical analyses are completed.

Table 5-2. Summary of selected radiological INEEL OP water surveillance analytical results, 2001

Analyte	Range of Concentrations (pCi/L ± 2s)						Background Concentration for the Snake River Plain Aquifer	Drinking Water Standard
	Sites on the INEEL			Boundary, Distant and Surface water sites				
	Min	Max	Median	Min	Max	Median		
Gross Alpha (as Thorium–230)[a,c]	<MDC	5.4 ± 2.0	<MDC	<MDC	4.9 ± 2.3	<MDC	0 – 3	15
Gross Beta (as Cesium-137)[a,c]	<MDC	54.6 ± 2.6	2.35 ± 0.8	-1.9 ± 1.0	7.0 ± 1.1	2.2 ± 0.9	0 – 7	50[b]
Cesium-137[c]	<MDC	<MDC	<MDC	<MDC	<MDC	<MDC	0	200[b]
Tritium[c]	<MDC	12780 ± 250	1640 ± 110	<MDC	150 ± 90	<MDC	0 – 40	20,000
Tritium[c,d]	<MDC	101 ± 8	16 ± 6	<MDC	169 ± 9	16 ± 6	0 – 40	20,000
Strontium-90[c]	<MDC	15.6 ± 2	5.3 ± 1.9		N/A		0	8[b]
Technetium-99[c]	<MDC	41 ± 10	4.9 ± 1.9		N/A		0	900[b]

a. The terms "as thorium-230" and "as cesium-137" refer to the radionuclide used to calibrate the instrument and do not imply that the activities present are due to the presence of these specific radionucides.
b. Expressed as a cumulative annual dose of 4 millirem/year. For unspeciated gross beta, 50 pCi/L is used as an action level; a activity-concentration is calculated for specific nuclides; e.g. for cesium-137, 4 millirem is equivalent to 200 pCi/L, if cesium-137 were the only detectable radionuclide.
c. MDC for gross alpha and gross beta radioactivity is approx. 2.5 and 1.4 pCi/L, cesium is typically >6 pCi/L, for tritium by standard analysis methods MDC is 160 pCi/L and for tritium by enhancement method MDC is 10-15 pCi/L. The MDC for strontium-90 is approx. 1.5 pCi/L; The MDC for technetium-99 analyzed by the contract lab is 4-9 pCi/L (total or unfiltered), and 0.5 pCi/L for dissolved technetium-99 analyzed by ISU-EML.
d Tritium analyzed using an Electrolytic Enhancement Method. For onsite locations, this includes just those samples that did not exceed MDC for tritium by the standard method.

Gross Alpha Radioactivity

Results for samples from 12 locations during 2001 exceeded the MDC (approximately 2.5 pCi/L) for gross alpha radioactivity. All results were well below the MCL of 15 pCi/L.

Three onsite locations yielded samples with detectable gross alpha, with all detections very near the MDC. USGS 120 yielded detections during the second and fourth quarters of the year, including the maximum value observed, 5.4 ± 2.0 pCi/L. No gross alpha radioactivity trends are apparent for any monitored sites, and sites with gross alpha detections in 2001 are sites where other INEEL contaminants are not detected. Thus, onsite gross alpha detections are attributable to naturally occurring radionuclides (uranium and thorium isotopes). Nine boundary, distant, and surface water sites yielded detections also.

Gross alpha radioactivity levels for all sites were within the range expected for naturally occurring radioactivity due to uranium and thorium decay products in the aquifer and illustrate the range of activity typical for the Eastern Snake River Plain.

Gross Beta Radioactivity

Samples from 46 of 49 locations during 2001 contained gross beta radioactivity exceeding the MDC of approximately 1.4 pCi/L. Drinking water MCLs are based on an exposure limit equivalent to 4 millirem per year to the whole body, with a screening level of 50 pCi/L for gross beta radioactivity. Strontium-90, an INEEL contaminant present in ground water down gradient from INTEC, decays primarily with beta-particles and has an MCL of 8 pCi/L.

Gross beta radioactivity concentrations for samples collected from onsite wells ranged from less than the MDC to 54.6 ± 2.1 pCi/L. The highest observed gross beta activities were from samples collected at observation wells USGS 85 and USGS 112, where groundwater is known to have been impacted by historical waste disposal practices at INTEC. Gross beta concentrations for these sites have in general, been declining since INEEL OP monitoring began in 1994, however, results for individual sampling periods tends to fluctuate. Gross beta radioactivity trends, along with trends for strontium-90, for sites USGS 85 and 112 are presented in **Figure 5-4**.

Gross beta radioactivity concentrations in samples collected from the boundary, distant, and surface water sites ranged from less than the MDC to 7.0 ± 1.1 pCi/L. Concentrations for gross beta radioactivity across the eastern Snake River Plain aquifer can vary. Typical values range from less than the MDC to about 7 pCi/L (Knobel and others, 1992).

Gamma Spectroscopy

Gamma spectroscopy results are reported for cesium-137, potassium-40, and for any gamma-emitting isotope that might be detected. No cesium-137 results exceeded the MDC. In 2001, naturally-occurring potassium-40 was reported as detected in samples from six sites. The levels of potassium-40 detected are greater than that expected and are an artifact of the analysis process. Approximately 0.01% of all potassium naturally consists of radioactive potassium-40, resulting in background concentrations for the aquifer of approximately 0 – 7 pCi/L, significantly less than the detection level for this isotope (100 – 130 pCi/L). Potassium-40is the predominant radioactive component in most foods and human tissues (Eisenbud and Gesell, 1997). No other gamma-emitting radionuclides were identified.

Tritium

Tritium concentrations for onsite monitoring locations did not exceed the MCL of 20,000 pCi/L for any sample collected in 2001. Concentrations in onsite samples for 2001 ranged from less than the MDC to 12,780 ± 250 pCi/L. Nine onsite wells yielded tritium concentrations above the approximately 160 pCi/L MDC. The highest tritium concentrations are from USGS 65. The other onsite locations with detectable tritium are USGS 112, 85, 115, CFA 1, CFA 2, RWMC Production, USGS 87, and 104.

Samples from one boundary site, USGS 124, exceeded the MDC for tritium. This site has historically been at or above the standard tritium MDC, and reflects INEEL tritium disposal. No other boundary, distant, or surface water site exceeded the standard tritium MDC. Background levels of tritium in the Snake River Plain Aquifer range from 0 to 40 pCi/L (Knobel and others, 1992).

The onsite wells with detectable tritium are downgradient from TRA-INTEC and are known to have been impacted by historical waste disposal. Tritium concentrations for most of these wells continued to decrease through 2001. Wells USGS 65 and 115 near INTEC decreased 15% or more from 2000 levels, while concentrations for USGS 112 have held steady. Historical trends for these locations are presented in **Figure 5-1.**

As seen in **Figure 5-2**, tritium concentrations in USGS 85 have a similar downward trend. Concentrations at CFA 1 and CFA 2 have fluctuated, but generally decreased by about 8 - 15% in the last year. Monitoring at the RWMC production well and at USGS 87 and USGS 104 suggests relatively constant tritium concentrations, as shown in **Figure 5-3.**

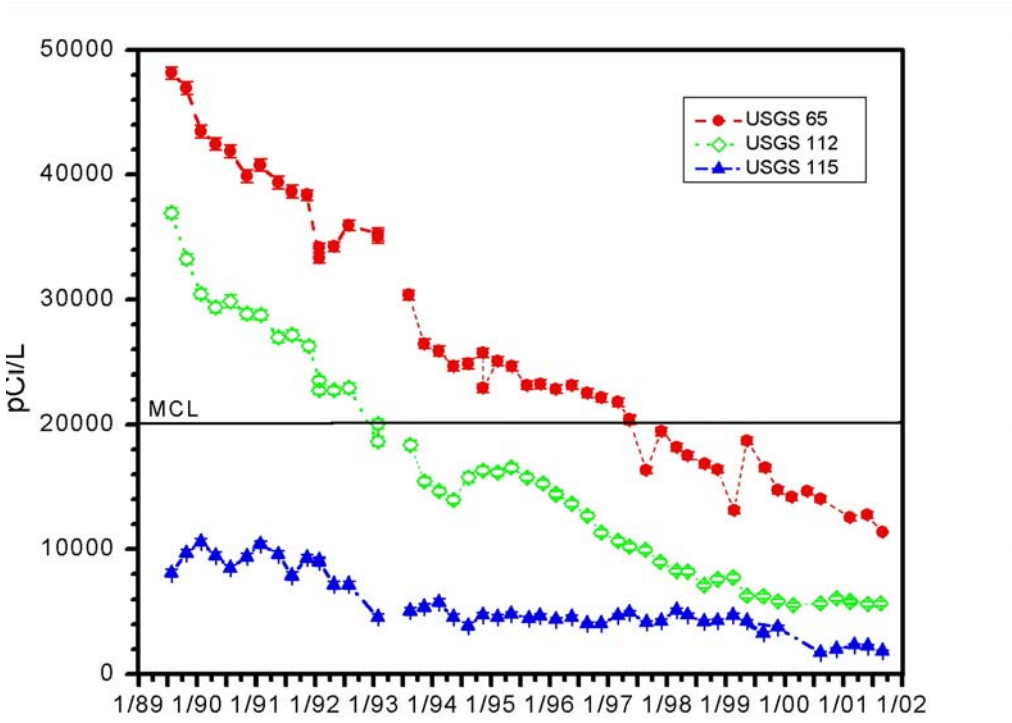


Figure 5-1. Tritium concentration over time, wells USGS 65, 112, and 115. Error bars are analytical uncertainty at 2 sigma.

An electrolytic enhancement technique was used to reanalyze samples that did not yield detectable tritium using the standard liquid scintillation analysis method. The MDC for this enriched or enhanced tritium analysis is about 10-15 pCi/L.

Onsite locations reanalyzed using the enhanced tritium method ranged from less than detectable levels to 102 ± 8 pCi/L, with a median concentration of 34 pCi/L. Samples from six onsite locations were reanalyzed. Results from one location, USGS 120 were clearly above expected ambient concentrations, with an average of 89 pCi/L for samples from this site. The remaining sites, P&W 2, Site 14, USGS 19, USGS 27, and USGS 100, showed tritium concentrations within background levels.

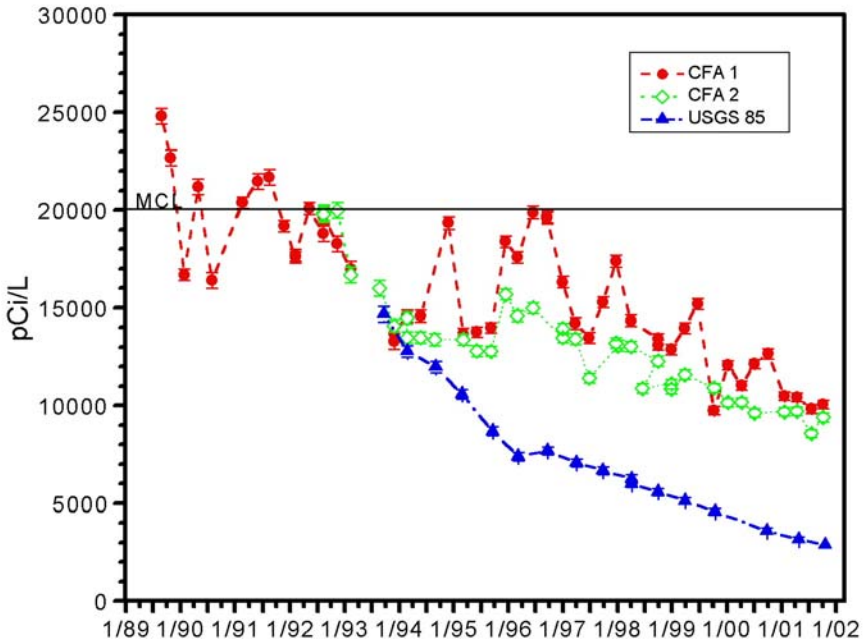


Figure 5-2. Tritium concentration over time, wells CFA 1, CFA 2, and USGS 85. Error bars represent 2-sigma uncertainty.

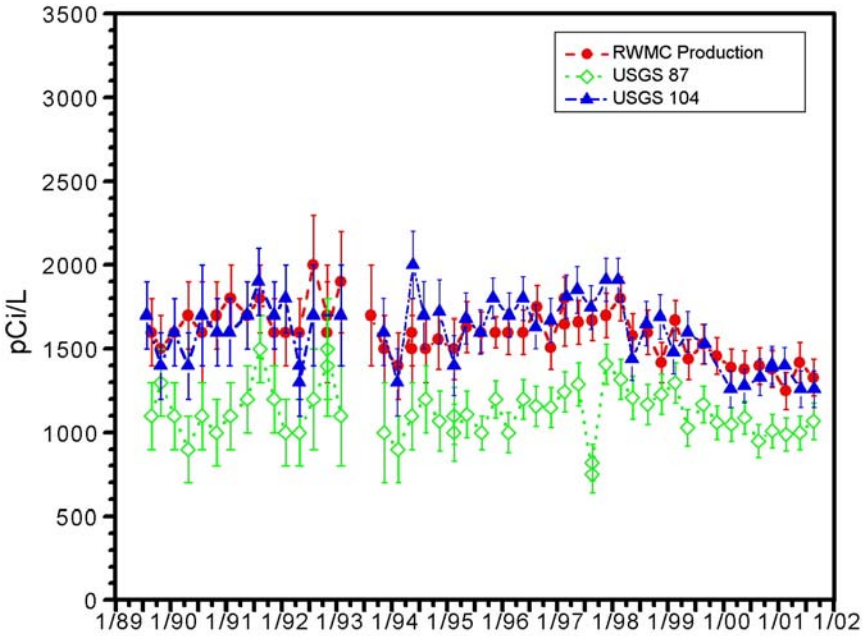


Figure 5-3. Tritium concentration over time, wells RWMC Production, USGS 87 and 104. Error bars represent 2-sigma uncertainty

Enhanced tritium analysis of boundary sites USGS 103, 108, 124, 125, 11, and 14 all showed some degree of INEEL tritium contamination, while other boundary sites, USGS 8 and Atomic City, did not. Concentrations ranged from less than detection to 178 ± 9 pCi/L, with a median value of 15.5 ± 6 pCi/L. Tritium samples from USGS 108 and 124 showed results clearly greater than that expected for background conditions, with concentrations for these sites ranging from the 178 ±9 at USGS 124 to the 124 ± 7 at USGS 108. Sites USGS 8, 11, and 14 show detectable tritium concentrations ranging from 36 ± 6 to 11 ± 6 pCi/L. Historic sampling at USGS 11 and 14 has revealed the presence of INEEL contaminants, chlorine-36 and iodine-129, suggesting that tritium detected there is also a result of INEEL contamination. Tritium concentrations for USGS 8 have historically averaged about 40-50 pCi/L, consistent with concentrations observed for Big Lost River sites for previous years, and other sites that are influenced by surface water or irrigation. Another boundary site, USGS 103, returned tritium concentrations just above sample-specific detection levels, at 11 ± 5 and 13 ± 4 pCi/L. An exhaustive study by Busenburg and others (2001) suggest that water from this well is influenced in a small degree from INEEL waste disposal.

Low-level tritium results for distant sites Alpheus Springs and Shoshone water supply average 38-46 pCi/L and also show nitrate values 1.3 to 2.0 mg/L, indicative of some degree of influence by surface water and irrigation. The tritium values observed for distant sites overall ranged from less than the MDC to 63 ± 10 with a median result of 32 pCi/L. Enhanced tritium analyses results for some samples were rejected during the second and third quarter analysis period due to an indication of tritium contamination problems in the ISU-EML. Enhanced tritium analyses were not completed for fourth-quarter 2001 samples while this contamination problem was being

investigated and resolved. See the water surveillance quality assurance report (Hall 2003b) for more information.

Rupert (1997) suggests that when tritium concentrations exceed about 4.5 pCi/L for a specific site, some portion of that groundwater had been recharged since the advent of nuclear testing in the early 1950s. Differing degrees of mixing older and recent (post-1950's) water result in the range of natural tritium concentrations observed. Groundwater in the central portion of the Eastern Snake River Plain Aquifer where sources of recent recharge are absent or minimal, the tritium concentrations should be less than the ISU-EML MDC for enhanced tritium analysis.

Strontium-90

Samples from four onsite wells were analyzed for INEEL contaminant, strontium-90. At CFA 1 and CFA 2, strontium-90 was below the MDC of about 1 pCi/L. In wells USGS 85 and USGS 112, strontium-90 appeared to be the predominant source of gross beta radioactivity, with concentrations of 3.3 ±0.72 and 3.57 ± 0.8 pCi/L and from 15 ± 2.8 to 23.6 ± 1.0 pCi/L, respectively.

Strontium-90 concentrations along with the gross beta radioactivity are shown in **Figure 5-4**. Assuming that strontium-90 is in equilibrium with yttrium-90, the counting instrument will see two beta decays each time one strontium-90 decay occurs. If strontium-90 is the most significant beta-emitter and the detector system is sensitive to the yttrium-90, there should be approximately a two-to-one ratio between gross beta radioactivity and the strontium-90 concentration. Allowing for the uncertainty in the compared results and a contribution by technetium-99, **Figure 5-4** appears to confirm the approximate two-to-one relationship between gross beta radioactivity and strontium-90, and suggests that in these two wells strontium-90 is the major source of gross beta radioactivity.

Technetium-99

Technetium-99 is a fission product produced primarily in nuclear reactors, with a half-life of about 21,000 years, presumably introduced to the aquifer through the INTEC injection well and possibly through the TRA Warm Waste Ponds. This long half-life, coupled with the fact that technetium-99 does not occur naturally, makes this constituent useful as a tracer to evaluate groundwater movement through the aquifer.

Samples were collected for both total (unfiltered) technetium-99, analyzed by radiochemistry methods, and for dissolved (filtered) technetium-99 analyzed by ISU-EML using ion-selective filter disks for each location monitored. Samples were collected from six locations with concentrations by both methods combined ranging from less than the MDC (about 1-2 pCi/L for the ion-selective filter method and 3 to 9 pCi/L for the radiochemistry method) to 41 ± 10 pCi/L. The highest concentrations were measured in samples from well USGS 112 (12.6 ± 1.8 to 41 ± 10 pCi/L).

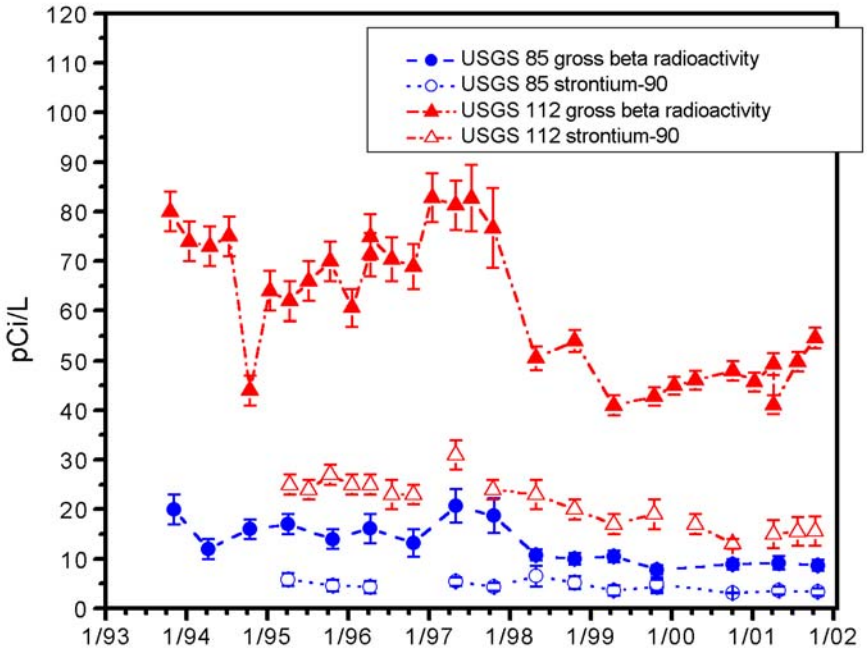


Figure 5-4. Comparison of gross beta radioactivity and strontium-90 concentrations in wells USGS 112 and 85.

Technetium-99 was also detected in samples from USGS 85, 115, CFA 1, and CFA 2, with concentrations ranging from 2.0 ± 0.3 to 6.2 ± 0.3 pCi/L for these wells. There were no detections for samples from USGS 104.

Samples were collected for analysis by both the radiochemistry and the ion-selective filter methods as a continuation of a special study conducted during 2000 by ISU-EML for analysis of technetium-99 (ISU-EML, 2000). Comparison of the radiochemistry and ion-selective filter technitium-99 results for 2001 showed agreement between values returned for each method. The ion-selective filter technitium-99 method provides a nearly ten-fold increase in sensitivity for analytical results. This comparison will be completed at the end of 2002.

Interprogram Comparisons of Water Results

The INEEL OP collects samples concurrently with the USGS and ESER. Goals for the water sampling conducted by these three organizations differ, but the use of similar analytical techniques serves to support meaningful interprogram data evaluation.

Comparisons of available 2001 monitoring results were made for various radiological parameters for all co-sampled locations. Nonradiological results were compared for locations co-sampled with the USGS on and near the INEEL. A summary of the sampling locations, frequency, analyses, and methods specific to interprogram comparisons appears in **Chapter 2**.

During 2001, replicate co-samples were collected with the USGS at 25 groundwater and surface water locations on and near the INEEL. Two sites on the Big Lost River were not sampled due to lack of flow in the river. In addition, the INEEL OP and the USGS collected replicate groundwater and surface water samples at 18 locations in the Magic Valley. The reduction in sample frequency during the fall of 2001 did not have a substantial impact on the number of replicate data pairs for 2001.

The INEEL OP and ESER co-sampled three springs and two drinking water supply wells south of the INEEL and in the Magic Valley. Additionally, INEEL OP and ESER both collected samples from the Atomic City and Mud Lake water supply systems. With 2001 sample results, these locations were considered to be co-sampled and included in comparisons.

Statistical comparisons were made for nonradiological analyses where the analyte of interest was present in both results of a data pair. Other criteria were used where a "less than" was reported for one or both samples. For radiological data, all analyses were used for statistical comparisons.

Linear regression analyses were applied to data where a sufficient number of replicate sample pairs were available. When such regressions were not meaningful, differences between replicate results were compared using histograms of the differences and evaluated with paired t-tests to compare population means. Relative percent differences are used for comparison when data are too limited (not enough data pairs) for comparison by other means. The linear regression is used because it can provide both an estimate of the mean difference between the INEEL OP result and co-sampling agency result, quantified by the y-intercept, and an estimate of the mean of y for a given x (shown by the slope of the regression). Hypothesis testing is used to determine if the y-intercept and slope terms are significant, as evidenced by associated t-statistics and probability values. Also displayed on the regression graphs are the 95% confidence interval about the regression line, and a 95% confidence interval for the predicted y value for a given x. If the more powerful regression is not statistically significant and meaningful, then a paired t-test is computed to determine if there is a significant difference between the paired data. Where censored data are presented (results reported simply as "<") relative percent differences and comparisons relative to the reporting level are made.

Linear regressions were determined meaningful where a combination of factors applied; y-intercept and slope coefficients appeared reasonable (a positive slope approaching 1), the correlation coefficient (R) is sufficiently large (generally > 0.80) and associated probability values (P for intercept, P for slope) for the slope and intercept indicate that the values are statistically significant (based on t-test statistics for $\alpha = 0.05$, or 95% confidence). Also reviewed were regression assumptions that residuals (the difference between the data value and the value predicted by the regression) versus predicted values were randomly distributed and that the residuals themselves were normally distributed, and that the standard deviation of the residuals was small compared to the magnitude of the data. These plots were assessed qualitatively and are not presented here. The regression parameters are presented for all data sets where there are a sufficient number of data pairs. If the regression was not significant then t-test results, a summary of the mean differences and a histogram of these differences are presented.

Nonradiological Results Comparisons

Linear Regression Comparisons

Samples collected by INEEL OP for nonradiological analyses are analyzed by the Idaho Bureau of Labs (IBL) in Boise and replicate samples from the USGS for nonradiological parameters are analyzed at the National Water Quality Laboratory (NWQL).

Regression results were meaningful for replicate data for chloride, chromium, nitrate plus nitrite, sodium, and sulfate. As summarized in **Table 5-3**, and depicted in **Figures 5-5** through **5-9**, linear regression comparisons of INEEL OP and USGS results showed excellent agreement for replicate data. Such agreement was not found for total phosphorus.

Table 5-3. Regression parameters with 95% confidence intervals for the replicate samples collected by the USGS and the INEEL OP, 2001

Analyte	y-intercept	P for intercept	Slope	P for slope	R	SD of the residual	Number of replicate sample sets
Chloride	0.40 ± 0.36	0.227	0.99 ± 0.007	$<10^{-4}$	0.999	2.05	61
Chromium	2.16 ± 1.38	0.140	1.05 ± 0.02	$<10^{-4}$	0.997	4.43	15
Nitrate + nitrite (as nitrogen)	0.01 ± 0.02	0.570	0.93 ± 0.01	$<10^{-4}$	0.997	0.07	28
Total Phosphorus	0.01 ± 0.004	0.123	0.38 ± 0.20	0.089	0.490	0.240	13
Sodium	0.04 ± 0.51	0.932	0.98 ± 0.02	$<10^{-4}$	0.990	1.55	34
Sulfate	0.55 ± 0.60	0.375	0.96 ± 0.01	$<10^{-4}$	0.9994	1.55	15

Chloride

Sixty-one replicate sample sets were collected for chloride in 2001. Regression analyses showed good agreement (**Figure 5-5).** The p-value for the y-intercept and slope indicate that the intercept does not differ from zero, and confirms that the slope does. Correlation coefficient (R) and the standard deviation indicated that the regression model reasonably predicts the relationship between USGS and INEEL OP chloride results. Because the USGS collects a filtered sample (dissolved chloride) while the INEEL OP collects an unfiltered sample (total chloride), this data agreement suggests that since there is no difference between the two, chloride present is largely in dissolved form.

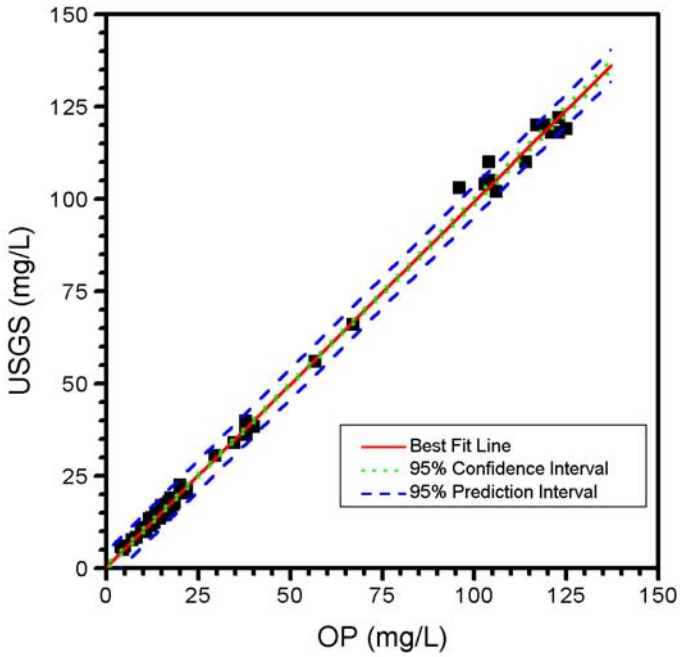


Figure 5-5. Concentrations of chloride reported for replicate samples, INEEL OP versus USGS on and near the INEEL, 2001.

Chromium

Twenty-six replicate dissolved chromium results were available for 2001. Seven results were less than the 2 µg/L MDC for the INEEL OP, and nine were reported as less than the 10 µg/L MDC for the USGS. EPA guidance suggests that for replicate samples in which the concentrations are less than five times the MDC, results are comparable if they differ by less than the sample MDC (EPA, 1994). All 16 of these replicates differed by less than the sample MDC.

Regression analyses, presented in **Figure 5-6**, showed very good agreement, with an intercept that does not differ from zero and a slope close to 1. Chromium was detected in both samples for 15 replicate pairs. Although the number of data pairs is small, the regression is reasonably strong, as evidenced by the small uncertainty for the slope, the high correlation coefficient (R), and the relatively small standard deviation for the regression.

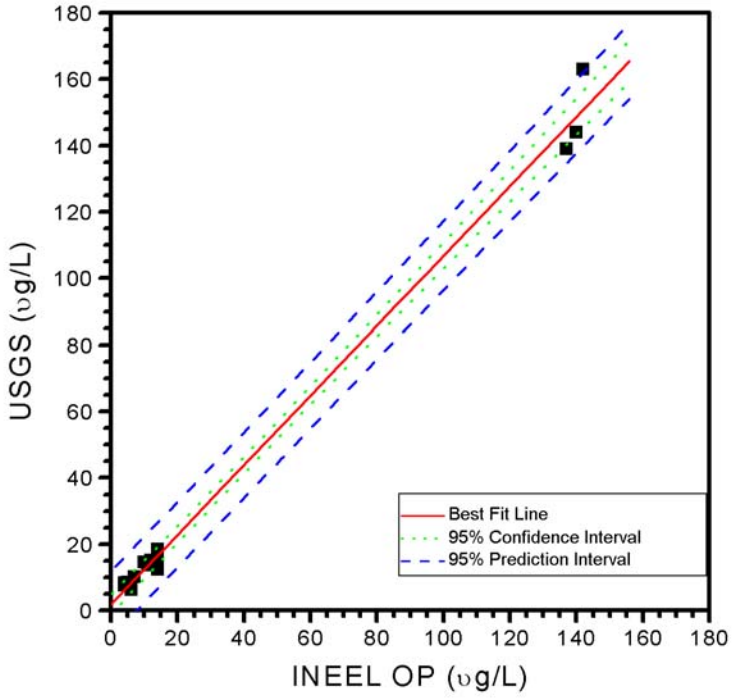


Figure 5-6. Concentrations of chromium reported for replicate samples, INEEL OP versus USGS on and near the INEEL, 2001.

Nitrate plus Nitrite as Nitrogen and Total Phosphorus as P

Regression analysis for the 28 replicate values for nitrate plus nitrite for INEEL OP and USGS results (**Figure 5-7**) also show good agreement. The slope suggests a small difference between USGS and INEEL OP results (slope of 0.93 and uncertainty of 0.01). The p-value for the y-intercept indicates an intercept indistinguishable from zero.

Replicate analyses for total phosphorus as P were available for 28 sample pairs, with total phosphorus detected for both samples for 13 of these sample pairs. All results exceeded the 0.005 mg/L MDC detection level for the INEEL OP. Fifteen results for USGS samples were less than the reporting level (0.018 – 0.020 mg/L) MDC for their analyzing laboratory. Regression analysis of the 13 sample pairs where both had detections failed to yield a meaningful regression. Because most of the data pairs included censored data, further statistical analysis was not completed.

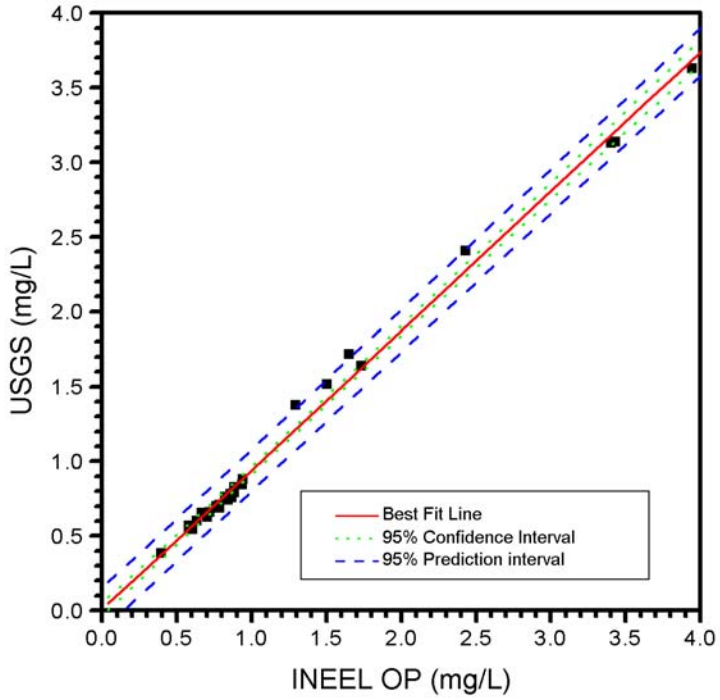


Figure 5-7. Concentrations of dissolved nitrite plus nitrate as nitrogen reported for replicate samples, INEEL OP versus USGS on and near the INEEL, 2001.

Sodium and Sulfate

There were 15 replicate results for sulfate and 34 replicate results for sodium. Sulfate results shown in **Figure 5-8** demonstrate good agreement, with a slope of 0.96 ± 0.01 and a y-intercept not differing from zero. The regression analyses presented in **Figure 5-9** indicate that the sodium results are well correlated with a slope of 0.98 ± 0.02 and a y-intercept not different from 0.

Relative Percent Differences Comparisons

Relative percent differences show excellent agreement for all of the analytes that could not be compared with linear regressions. **Table 5-4** demonstrates the comparison of the concentrations of these constituents reported in replicate samples during 2001.

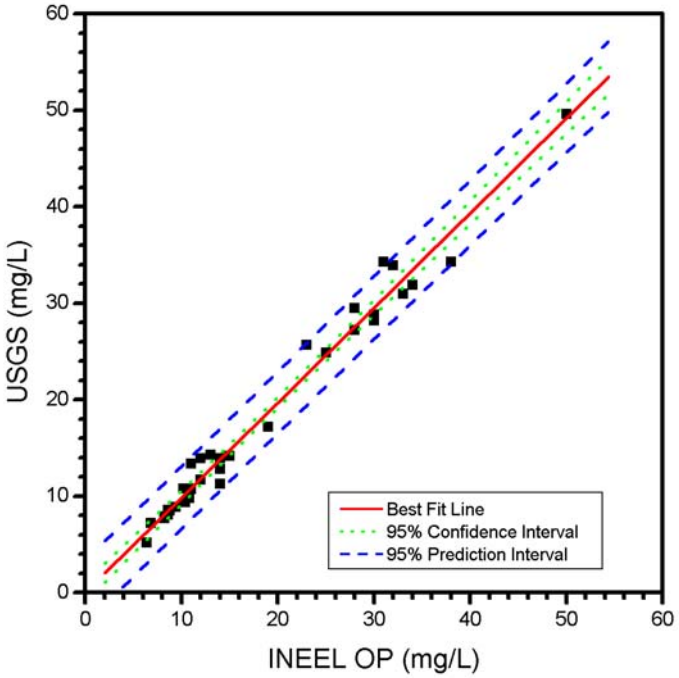


Figure 5-8. Concentrations of sulfate reported for replicate samples, INEEL OP versus USGS on and near the INEEL, 2001.

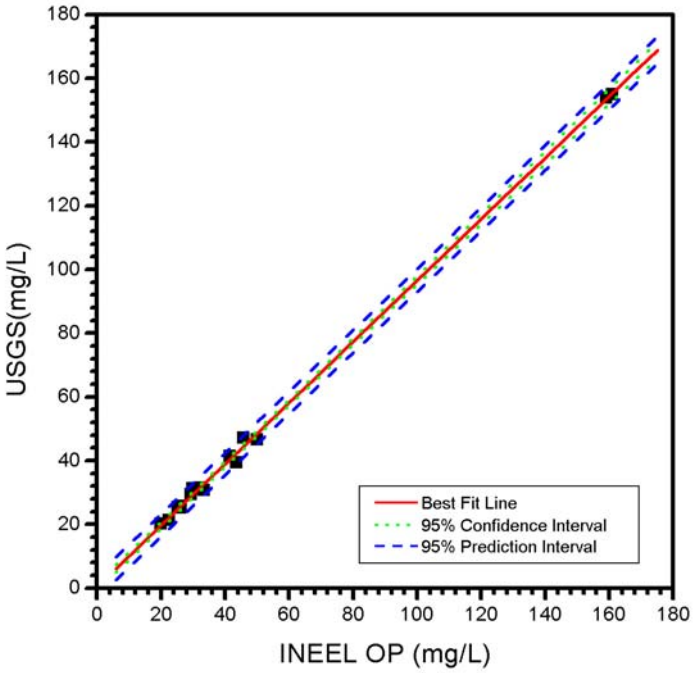


Figure 5-9. Concentrations of sodium reported for replicate samples, INEEL OP versus USGS on and near the INEEL, 2001.

Table 5-4. Comparison of common ion, nutrient, and trace metal concentrations reported for replicate samples, 2001

Analyte	Number of replicate sample pairs	Number of pairs where analyte detected in both samples	Number of replicate pairs where relative percent difference <20%, or where results are within +/- detection limit	Percent of replicate samples with comparable results
Barium	2	2	2	100
Chromium	26	15	11[a]	100
Chloride	61	61	(compared by linear regression)	
Lead	2	0	2	100
Manganese	2	0	2	100
Sodium	34	34	(compared by linear regression)	
Sulfate	15	15	(compared by linear regression)	
Nitrite plus nitrate as nitrogen	34	34	(compared by linear regression)	
Phosphorus as P	28	13	28[b]	100
Zinc	2	2	2	100

[a] Fifteen replicate pairs compared by linear regression.
[b] Linear regression was not meaningful.

Two replicate sample sets were collected for barium, lead, manganese, and zinc from USGS 65.

The INEEL OP and the USGS both collected filtered samples for phosphorus during 2001. Only 13 of 28 pairs yielded detections in both samples, and regression analysis on these data did not result in a good regression. The remaining samples did not vary by more than +/- the detection level (0.018-0.020 mg/L for USGS and 0.005 for INEEL OP). Two factors should be noted concerning phosphorus comparisons; the reporting level for the National Water Quality Laboratory (NWQL), the USGS analyzing laboratory, is a factor of four higher than the Idaho Bureau of Laboratories (IBL) for phosphorus, and the USGS analyzes for orthophosphorus instead of total phosphorus as P (as does the IBL). Prior to 2000, OP collected unfiltered samples for nutrients, and identified systematic differences between OP nutrient results and USGS results. Nutrient comparisons improved following this change to collecting a filtered sample. INEEL OP analyses are for total phosphorus as P instead of orthophosphorus as P because of the short holding time for the analysis at IBL (48 hours), and because total phosphorus is more conservative. Analysis for total phosphorus as P will account for the organic or bio-available phosphorus (as is measured by the orthophosphorus) as well as inorganic phosphorus.

In summary, comparisons of INEEL OP and USGS results for nonradiological analytes demonstrate excellent agreement for nearly all replicate data. Such close agreement in results indicates that data between respective programs are comparable, and that there are no significant biases introduced by differences in sample collection or analysis methods for replicate samples collected during 2001.

Radiological Results Comparisons

Replicate sample results for gross alpha, gross beta, tritium, and strontium-90 were available for samples collected by the INEEL OP and the USGS on and near the INEEL, and for the USGS Magic Valley sampling program, an area including sites from the southern boundary of the INEEL to the Snake River between Twin Falls and Hagerman. Replicate sample results are also available for the seven locations INEEL OP and ESER co-sample in the Magic Valley.

Differences in the methodology used by an individual agency can influence interprogram comparisons. **Table 5-5** provides a summary of collection and analysis methods used by the INEEL OP, ESER, and the USGS and their possible impacts on comparability of gross alpha and gross beta radioactivity results.

For each analyte, regression analysis was attempted first. If that regression was meaningful based on the criteria presented in the introduction to the previous section, **Interprogram Comparisons**, a plot of the data was presented without further analysis presented. **Table 5-6** indicates the analyses that could be applied to each analyte.

When the regression results were not meaningful, the data were compared using a paired t-test to evaluate whether the means of the data were statistically different. **Table 5-7** summarizes these results. To characterize the differences between replicates, the result obtained by the INEEL OP was subtracted from ESER or USGS result. **Table 5-8** outlines these differences for each of the respective analytes.

Histograms of these differences were generated to identify outliers and illustrate how the differences are distributed with a normal curve fitted to the histogram. Where the INEEL OP collected field replicates , the mean of these replicates and the pooled analytical errors were compared to the replicate results from ESER and USGS.

Gross Alpha Radioactivity

A total of 54 replicate results for gross alpha radioactivity were available: 14 co-sampled with ESER, 22 with the USGS on and near the INEEL, and 18 with the USGS in the Magic Valley.

With regression results not meaningful, paired t-test analysis indicated that, at a 95% confidence level, the means of gross alpha radioactivity measurements made by the INEEL OP differed from those of ESER, while results compared with the USGS on and around the INEEL and in the Magic Valley, were not statistically different. Comparison results are presented in **Tables 5-8, 5-9,** and **5-10**. Histograms of these differences are presented in **Figures 5-10, 5-11**, and **5-12**.

INEEL OP gross alpha radioactivity results tended to be greater than that of the ESER, and with the USGS. Differences were small, less than the typical 2-s uncertainty for these measurements. Histograms of differences (**Figures 5-10,11,12**) show that differences between the co-sample results appear to be normally distributed, thus not indicating an inconsistent bias in the compared

results. The differences between INEEL OP and ESER may be explained by the difference between instruments used. See Table 5-5 for further discussion.

Table 5-5. Sampling and analysis techniques for gross alpha and gross beta samples collected by the INEEL OP, USGS and ESER, 2001

Sampling or analytical technique	INEEL OP	ESER	USGS-INEEL Monitoring Program	USGS-Magic Valley Monitoring Program	Effect on measured concentration
Manufacturer, model, and operational mode for gas-proportional counting system, and typical count time.	Protean 5", automatic feed, thin-window, 300 minutes.	Canberra model 2404 1.85" (47 mm), automatic feed, thin-window, 125 minutes.	For alpha, scintillation counter and 60 minutes. For beta, Tennelec 2", automatic feed, thin-window ($85\mu g/cm^2$) 20 minutes.	Tennelec model 5100 automatic feed, thin-window, 125 minutes.	Differences in radiation detector models' operation and maintenance, and standard count-times can have significant impacts on counting efficiency and resulting MDC. Larger detectors and longer count times increase sensitivity of the measurement.
Calibration isotope[a] gross alpha analyses	Thorium-230	Thorium-230	Plutonium-239	Thorium-230	In general, a lower energy standard would result in a slightly higher reported concentration.
Calibration isotope[a] gross beta analyses	Cesium-137	Cesium-137	Cesium-137	Cesium-137	In general, a lower energy standard would result in a slightly higher reported concentration. In the past, strontium-90 has been used as a calibration isotope for gross beta by some laboratories.
Filtration	Not Filtered	Not Filtered	Not Filtered	Filtered	Samples that are not filtered include dissolved and suspended constituents, which may result in a higher concentration than filtered samples containing only the dissolved fraction.
Preservation	Nitric acid added in the field	Nitric acid added in the field	Nitric acid added in the field	Nitric acid added in the field	Not preserving the sample in the field may result in radionuclides present in the sample adhering to the sample container, which could result in a lower measured concentration in the unpreserved sample.

a. The lower the energy of the decay particle, the less efficient the detector. Because the concentration is determined by dividing the number of counts by the efficiency, calibration with a lower energy particle yields a higher concentration. Peak energies are listed below (from Shleien, 1992).(1) americium-241: 5.49 MeV alpha particle (85%) (2). Strontium-90/yttrium-90: 2.28 MeV beta particle (yttrium-90, 100%) (3) plutonium-239: 5.16 MeV alpha particle (73%) (4). 0 .55 MeV beta particle (strontium-90, 100%) (5). thorium-230: 4.69 MeV alpha particle (76%) (6). cesium-137: 1.17 MeV beta particle (5%) 0.51 MeV beta particle (95%).

Table 5-6. Summary of linear regression[a] parameters with 95% confidence intervals for the replicate samples collected by INEEL OP, USGS, and ESER, 2001. Shaded row indicates a meaningful regression.

Analyte	Co-sampling Agency	y-intercept	P for intercept	Slope	P for slope	R	SD of the residual	Number of replicate sample sets
Gross Alpha	ESER	0.50 ± 0.30	0.125	0.04 ± 0.16	0.790	0.078	0.655	14
	USGS (INEEL)[a]	1.43 ± 0.08	$<10^{-4}$	0.03 ± 0.03	0.409	0.185	0.275	22
	USGS (MV)[b]	2.02 ± 0.45	0.0006	0.20 ± 0.22	0.395	0.213	1.047	18
Gross Beta	ESER	2.44 ± 1.00	0.032	0.44 ± 0.25	0.104	0.452	1.548	14
	USGS (INEEL)[a]	4.26 ± 0.10	$<10^{-4}$	-0.01 ± 0.01	0.816	-0.053	0.282	22
	USGS (MV)[b]	1.47 ± 0.43	0.004	0.24 ± 0.13	0.071	0.435	0.881	18
Cesium-137	USGS (INEEL)[a]	7.2 ± 5.4	0.189	-9.5 ± 5.6	0.100	-0.311	26.8	29
Tritium	ESER	29 ± 27	0.306	0.63 ± 0.52	0.248	0.331	87.3	14
	USGS (INEEL)[a]	-64 ± 64	0.319	1.02 ± 0.01	$<10^{-4}$	0.995	411	61
	USGS (MV)[b]	22 ± 6.2	0.002	-0.02 ± 0.11	0.8795	-0.039	17.3	18
	USGS (MV)[bc]	-7.5 ± 4.2	0.096	1.07 ± 0.14	$<10^{-4}$	0.887	7.98	18
Strontium-90	USGS (INEEL)[a]	0.75 ± 0.70	0.309	0.90 ± 0.07	$<10^{-4}$	0.977	1.77	11

[a] USGS on and near the INEEL
[b] USGS in the Magic Valley
[c] Tritium results using electrolytic enhancement and liquid scintillation.

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Table 5-7. Summary of paired t-tests for replicate samples analyses, 2001. Shaded cells indicate means that differ at the 95% confidence level.

Analyte	Co-sampling Agency	Mean of Data (pCi/L)	Variance of data	Number of Replicate Samples	t-statistic	Probability (P-Value)	Conclusion (at 95% Probability
Gross Alpha							
	OP with ESER	1.55 0.57	1.31 0.40	14	2.92	0.0120	Means are significantly different
	OP with USGS (INEEL)[a]	1.65 1.47	3.34 0.07	22	0.46	0.6484	Means are not significantly different
	OP with USGS (MV)[b]	1.68 2.35	1.24 1.08	18	-2.11	0.0504	Means are not significantly different
Gross Beta							
	OP with ESER	3.62 4.05	2.89 2.78	14	-0.90	0.3849	Means are not significantly different
	OP with USGS (INEEL)[a]	1.50 4.24	1.25 0.08	22	-11.0	<0.0001	Means are significantly different
	OP with USGS (MV)[b]	3.04 2.21	2.87 0.90	18	2.30	0.0345	Means are significantly different
Cesium-137							
	OP with USGS (INEEL)[a]	0.36 3.81	0.82 765	29	-0.66	0.5119	Means are not significantly different
Tritium							
	OP with ESER	27.6 46.6	2196 7905	14	-0.83	0.4235	Means are not significantly different
	OP with USGS (INEEL)[a]	Compared by linear regression					
	OP with USGS (MV)[b]	41.8 21.7	1375 280	18	2.07	0.0538	Means are not significantly different
Tritium[c]							
	OP with USGS (MV)[c]	Compared by linear regression					
Strontium-90							
	OP with USGS (INEEL)[a]	Compared by linear regression					

a. Locations on and near the INEEL.
b. Distant, Magic Valley locations.
c. Tritium analyzed using an electrolytic enhancement

Table 5-8. Summary of mean differences between results of replicate pairs, 2001

Analyte	Co-sampling Agency	Mean difference (INEEL OP) (pCi/L)	Standard Deviation	Number of replicate pairs
Gross alpha				
	ESER	-0.99	1.26	14
	USGS (INEEL)[a]	-0.18	1.80	22
	USGS (MV)[b]	0.67	1.35	18
Gross beta				
	ESER	0.42	1.76	14
	USGS (INEEL)[a]	2.74	1.16	22
	USGS (MV)[b]	-0.83	1.54	18
Cesium-137				
	USGS (INEEL)[a]	3.44	28.0	29
Tritium				
	ESER	18.9	85.7	14
	USGS (INEEL)[a]		Compared by linear regression	
	USGS (MV)[b]	14.5	44.2	18
Tritium[c]				
	USGS (MV)[b]		Compared by linear regression	
Strontium-90				
	USGS (INEEL)[a]		Compared by linear regression	

a. Locations on and near the INEEL
b. Magic Valley sampling locations
c. Tritium measured using an Electrolytic Enhancement Method

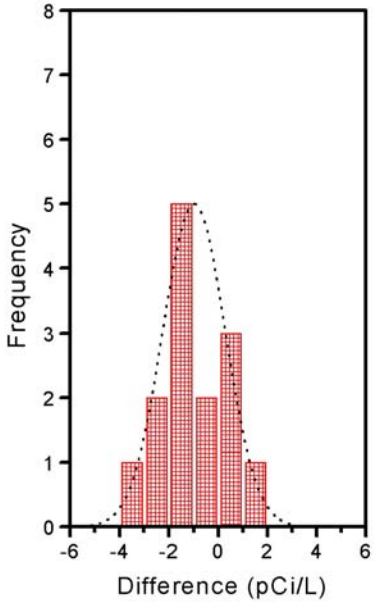

Figure 5-10. Histogram of differences between INEEL OP and ESER for gross alpha radioactivity, 2001.

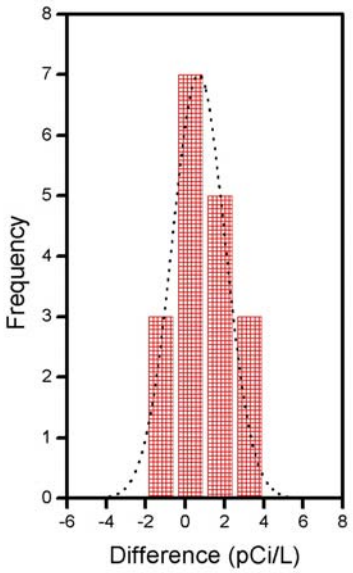

Figure 5-11. Histogram of differences between INEEL OP and USGS in the Magic Valley for gross alpha, 2001.

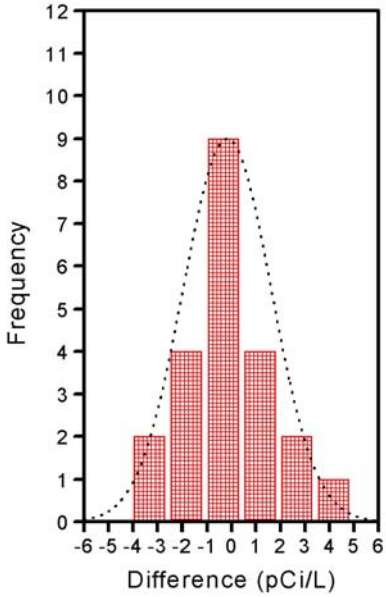

Figure 5-12. Histogram of differences between INEEL OP and USGS on and near the INEEL for gross alpha radioactivity, 2001.

Gross Beta Radioactivity

A total of 54 replicate results for gross beta radioactivity were available: 14 co-sampled with ESER, 22 with the USGS on and near the INEEL, and 18 with the USGS in the Magic Valley. Regression results were not meaningful for any compared gross beta radioactivity.

Paired t-test analyses, noted in **Table 5-7**, indicated that at a 95% confidence level, the mean of gross beta radioactivity measurements made by the INEEL OP are different from that of the USGS on and near the INEEL and in the Magic Valley. Differences between replicate samples for gross beta radioactivity, presented in **Table 5-8**, showed that INEEL OP results for 2001 were less than those of ESER and the USGS on and near the INEEL and greater than the USGS in the Magic Valley. Mean differences were at or less than the typical 2-s sample counting uncertainty for ESER and the USGS in the Magic Valley, with differences just greater than the typical sample-specific MDC for USGS on and near the INEEL. This difference is consistent with comparisons from previous years. Histograms of these differences, presented in **Figures 5-13, 5-14,** and **5-15** suggest that differences appear to be distributed normally. One replicate data pair for USGS in the Magic Valley and INEEL OP showed a difference of about 3.5 pCi/L, greater than other differences between data pairs, and may represent an outlier. Contributing factors for observed differences between USGS results and those of INEEL OP include detector size, and count times.

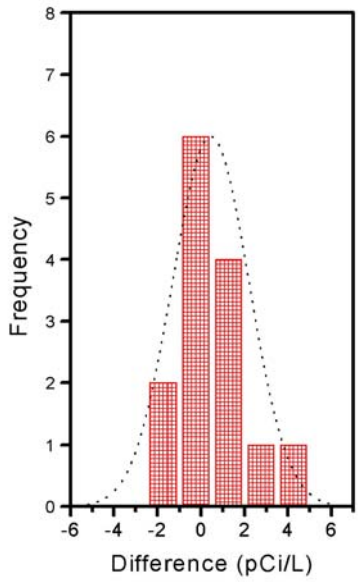

Figure 5-13. Histogram of differences between INEEL OP and ESER for gross beta radioactivity, 2001.

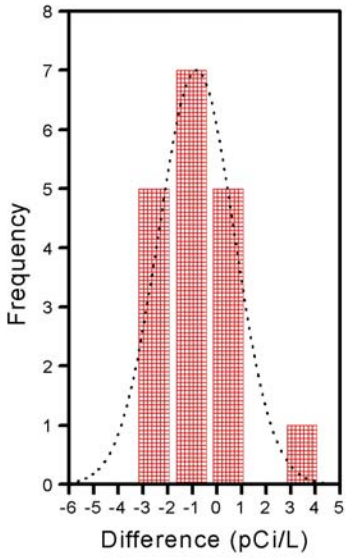

Figure 5-14. Histogram of differences between INEEL OP and USGS in the Magic Valley for gross beta radioactivity, 2001.

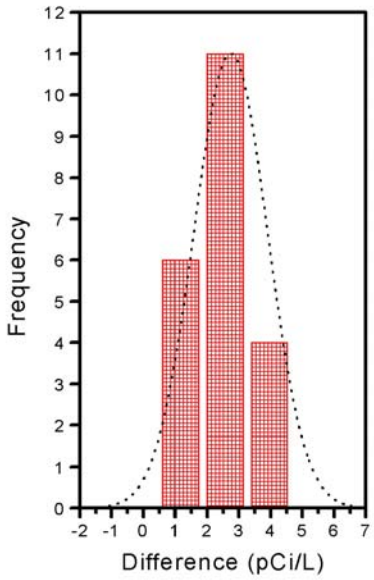

Figure 5-15. Histogram of differences between INEEL OP and USGS on and near the INEEL for gross beta radioactivity, 2001.

Cesium-137

All of the 29 replicate results available for cesium-137 were replicates with the USGS on the INEEL. Regression analysis was not meaningful, as noted on **Table 5-6**. Paired t-test analysis indicated that the means were not significantly different for cesium-137 analyses at a 95% confidence level. Mean differences, presented in **Table 5-8**, show that the USGS results on the INEEL were typically greater than the INEEL OP results. A difference likely due to the level of resolution (relatively high MDC) of the USGS results (about 100 pCi/L) compared to about 2.5 pCi/L for INEEL OP results. The large differences in MDC are factors of the smaller volumes analyzed (400 ml of sample analyzed for USGS and 1000 ml for INEEL OP) and the shorter counting times for those volumes (1 hour for USGS and 8 hours for INEEL OP). **Figure 5-16** presents the histogram of these results that shows differences that appear normally distributed.

Tritium

A total of 93 replicate results for tritium were available: 14 co-sampled with ESER, 61 with the USGS on and near the INEEL, and 18 with the USGS in the Magic Valley. As indicated in **Table 5-6**, regression results were not meaningful for locations co-sampled with the ESER and with the USGS in the Magic Valley, but were meaningful for locations co-sampled with the USGS on and near the INEEL.

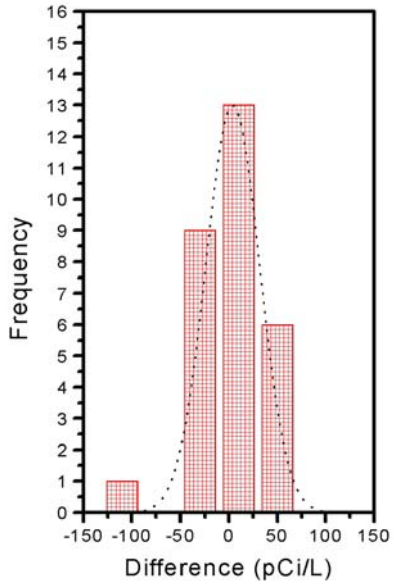

Figure 5-16. Histogram of differences between INEEL OP and USGS cesium-137 concentrations on and near the INEEL, 2001.

The regression results for sites co-sampled with the USGS on and near the INEEL (**Figure 5-17)** demonstrate very good agreement. The regression slope for 2001 comparisons (1.02 ± 0.01), combined with all supporting information, indicates excellent agreement between INEEL OP and USGS tritium on and near the INEEL.

Replicate tritium results for ESER and USGS in the Magic Valley, compared using t-tests, were not significantly different from INEEL OP results. Histograms of these differences are presented in **Figures 5-18** and **5-19,** show differences normally distributed**.**

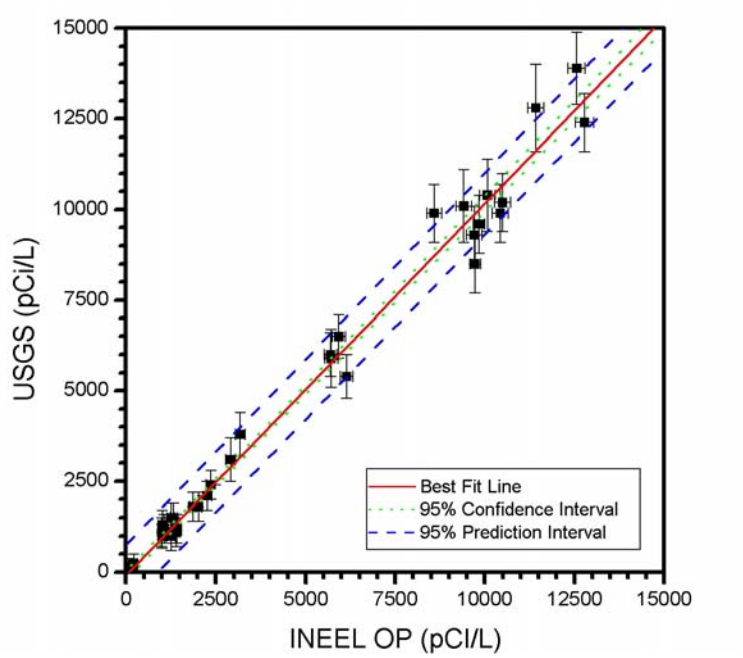

Figure 5-17. Comparison of replicate tritium results for INEEL OP and USGS for sites on and near the INEEL, 2001.

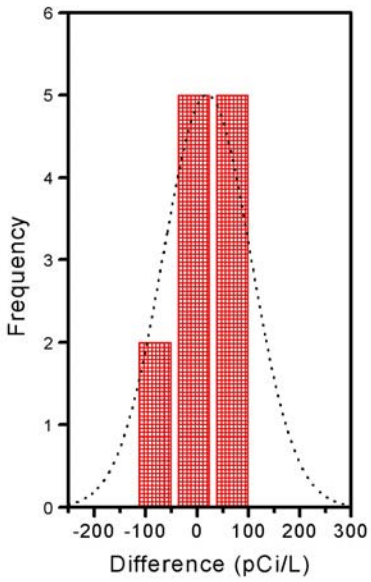

Figure 5-18. Histogram of differences between INEEL OP and ESER for Tritium, 2001.

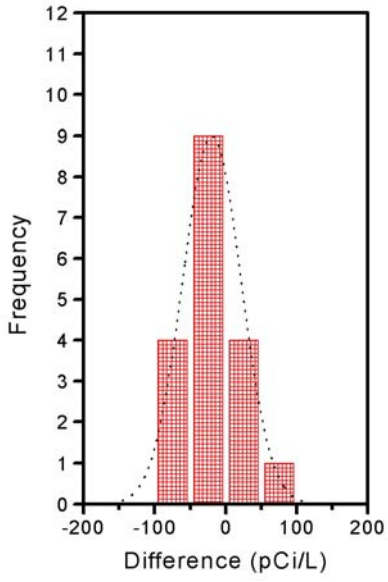

Figure 5-19. Histogram of differences between INEEL OP and USGS Magic Valley for Tritium by the standard method, 2001

Enhanced Tritium

The USGS National Water Quality Laboratory uses an enrichment and liquid scintillation method with longer counting times to measure tritium at very low levels. This method, with an MDC of approximately 3 pCi/L, about 100 times lower than liquid scintillation alone reported by the USGS on and near the INEEL, is best suited for tritium at background levels. ISU EML uses a similar electrolytic enrichment method to concentrate tritium in samples. This enrichment method lowers sample MDCs to less than 25 pCi/L (practice has show MDC values from 10-15 pCi/L), which is within the range typically observed for background levels of tritium for the eastern Snake River Plain Aquifer.

A total of 18 replicate environmental-level tritium samples were collected with the USGS in the Magic Valley. These results were compared with the tritium analysis results from the USGS National Water Quality Laboratory (**Figure 5-20**). The regression for low-level tritium results from ISU-EML and the USGS were comparable, with a slope of 1.07 ± 0.14, and a y-intercept indistinguishable from zero. When compared on an individual sample by sample basis, six of the 18 replicate data pairs for enhanced tritium differed by more than 3-times the pooled sample uncertainty. All six INEEL OP enhanced tritium results were higher than those for USGS. This apparent bias is suspected to be related to laboratory contamination issues at ISU-EML. Samples for enhanced tritium analysis are now processed in another facility away from the suspected source of tritium. The level of contamination was such that only the low-level samples were impacted. See the 2001 Water Wurveillance Quality Assurance Report (Hall 2003b) for more information.

Strontium-90

Eleven replicate results for strontium-90 for four locations co-sampled with the USGS on the INEEL were compared. Regression analysis of these data, shown on **Figure 5-23**, correlate reasonably well for such a small number of compared samples. The regression slope was 0.90 ± 0.07, suggesting that INEEL OP results for strontium-90, which are conducted by Paragon Analytics, Inc., a laboratory on subcontract to ISU-EML, were generally 10% greater than results from the USGS. The y-intercept for this regression was not distinguishable from zero.

Summary of Differences

While statistically significant differences (at the 95% confidence level) were observed for gross alpha and gross beta replicate results, these differences were relatively small compared to the concentrations observed. **Figure 5-22** summarizes the relative differences between INEEL OP results and replicate results from ESER and USGS on and near the INEEL and in the Magic Valley.

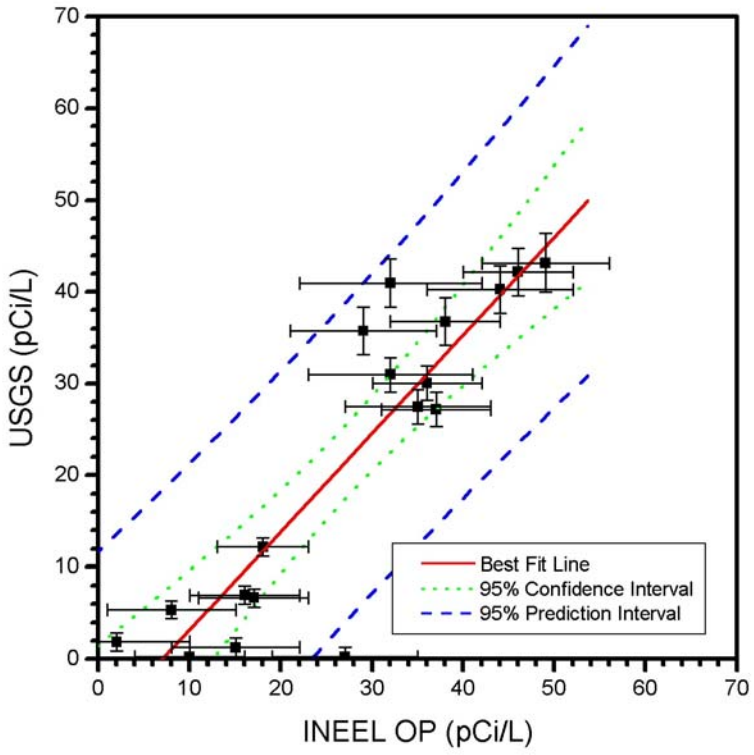

Figure 5-20. Comparison of replicate results for tritium by electrolytic enrichment and liquid scintillation for the USGS MV and INEEL OP, in the Magic Valley, 2001.

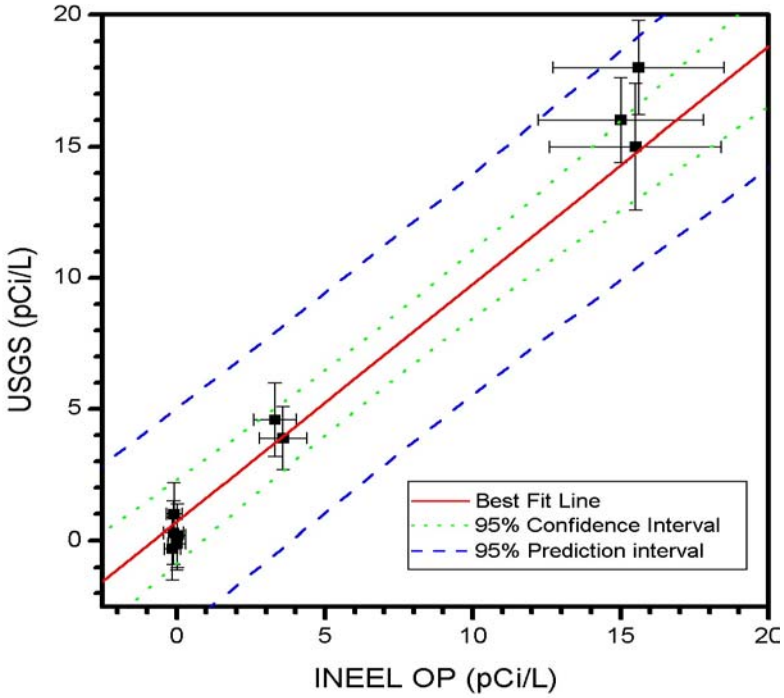

Figure 5-21. Comparison of replicate results for strontium-90, INEEL OP and USGS on and near the INEEL, 2001.

The x-axis (**Figure-22)** shows the mean and standard deviation of differences for individual replicate results divided by the absolute value of the INEEL OP result for that data pair. Dividing by the INEEL OP result serves to normalize the differences with the computation result being a "relative mean difference."

The mean relative differences for all data sets are within one standard deviation of the zero difference line. The range of relative differences is less than about 10 with one exception. This exception is cesium-137 compared with the USGS on and near the INEEL. The difference between INEEL OP and USGS MDC analysis methods (volumes analyzed and sample counting times, as previously discussed) can explain the wide range of relative difference (-65 to 145 with a mean of 40). While their respective analysis methods may be sufficient for the goals of the USGS and the INEEL OP, such a difference makes meaningful comparison difficult. However, replicate results for both the USGS on the INEEL and INEEL OP conclude that cesium-137 is not detectable in replicate samples collected. Such results do provide an informative example of the impact that differences in analytical methods can have on a given set of data.

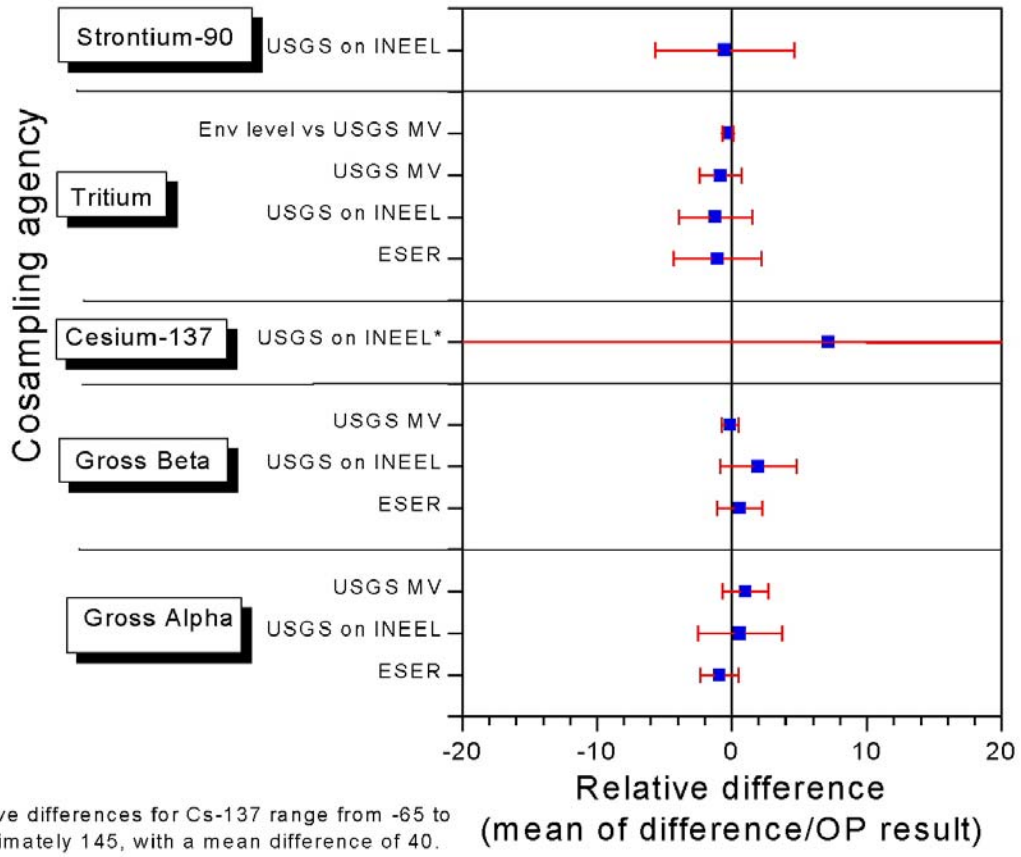

Figure 5-22. Summary of relative differences between INEEL OP results and replicate results from ESER and USGS on and near the INEEL and in the Magic Valley.

Comparison of replicate radiological results with ESER and with the USGS on and near the INEEL and in the Magic Valley did show some differences, the biases appeared relatively small (much less than any drinking water standard) and could be explained by differences in laboratory and sample collection methods. In general, comparison of results from these co-sampling organizations verified that, while the differences between replicate results obtained by these agencies and INEEL OP may have statistical significance (i.e. failing the statistical criteria), the magnitude of any differences is small compared to the magnitude of the data and the reporting levels.

References

Bartholomay, R.C., B.R. Orr, M.J. Liszewski, and R.G. Jensen. *Hydrologic Conditions and Distribution of Selected Radiochemical and Chemical Constituents in Water, Snake River Plain Aquifer, Idaho National Engineering Laboratory, Idaho, 1989 through 1991*. U.S. Geological Survey Water-Resources Investigations Report 95-4175 (DOE/ID-22123), 1995.

Bartholomay, R.C., B.J. Tucker, D.J. Ackerman, and M.J. Liszewski. *Hydrologic Conditions and Distribution of Selected Radiochemical and Chemical Constituents in Water, Snake River Plain Aquifer, Idaho National Engineering Laboratory, Idaho, 1992 through 1995*. U.S. Geological Survey Water-Resources Investigations Report 97-4086 (DOE/ID-22123), 1997.

Eisenbud, M., and T. Gesell. *Environmental Radioactivity from Natural, Industrial, and Military Sources*. 4th Ed. Academic Press,1997.

United States Environmental Protection Agency (EPA). 1994. Contract laboratory program national functional guidelines for inorganic data review. EPA 540/R-94/013. .

Hall, L. F. *Water Quality trends for Surveillance Monitoring Sites, 2001.* State of Idaho INEEL Oversight Program. OP-03-02, 2003a.

Hall, L. F. *Quality Assurance /Quality Control Report for the Environmental Surveillance Program Water Samples, 2001.* State of Idaho INEEL Oversight Program. OP-03-03, 2003b.

Hall, L. F. *Comparison of Major Ion Water Chemistry for the State of Idaho INEEL Oversight Program Environmental Surveillance Water Monitoring Data Upgradient (USGS 27 and Mud Lake Water Supply) With Data From other Sources*. State of Idaho INEEL Oversight Program. OP-99-01, 1999.

Hem, J.D. *Study and Interpretation of the Chemical Characteristics of Natural Water*. U.S. Geological Survey Water-Supply Paper 2254. 1985.

Idaho State University Environmental Monitoring Laboratory. *Technetium-99 Measurement Using 3M™ Empore™ Rad Disks*. July 1, 2000.

Knobel, L.L., B.R. Orr, and L.D. Cecil. *Summary of Background Concentrations of Selected Radiochemical and Chemical Constituents in Groundwater from the Snake River Plain Aquifer, Idaho. Estimated from an analysis of previously published data*: Journal of the Idaho Academy of Sciences. 28 (June 1992)

Knobel, L.L., R. S. Bartholomay, B. J. Tucker, L. M. Williams and L. D. Cecil. *Chemical Constituents in Groundwater from 39 Selected Sites with an Evaluation of Associated Quality Assurance Data, Idaho.* U.S. Geological Survey Open-File Report 99-246 (DOE/ID-22159), 1999

Mann, L.J. *Radionuclides, Metals, and Organic Compounds in Water, Eastern Part of the A&B Irrigation District, Minidoka County, Idaho*. U.S. Geological Survey Open-File Report 90-191 (DOE/ID-22087), 1990.

Michel, R.J. *Tritium Deposition in the Continental United States 1953-1983*. USGS Water Resources Investigation Report 89-4072, 1989.

Orr, B.R., D.L. Cecil, and L.L. Knobel. *Background Concentrations of Selected Radionuclides, Organic Compounds, and Chemical Constituents in Groundwater in the Vicinity of the Idaho National Engineering Laboratory.* U.S. Geological Survey Water-Resources Investigations Report 91-4015 (DOE/ID-22094), 1991.

Rupert, M.G. *Nitrate (NO2+ NO3-N) in Ground Water of the Upper Snake River Basin, Idaho and Western Wyoming 1991-95.* U.S. Geological Survey Water Resources Investigations Report 97-4174. 1997.

Rupert, M.G.. *Analysis of Data on Nutrients and Organic Compounds in Groundwater in the Upper Snake River Basin, Idaho and Wyoming, 1980-91.* U.S. Geological Survey. Water Resources Investigations Report 94-4135.

Robertson, J.B., R. Schoen, and J.T. Barraclough. *The Influence of Liquid Waste Disposal on the Geochemistry of Water at the National Reactor Testing Station, Idaho:1952-1970*, U.S. Geological Survey Open File Report IDO-22053, 1974.

United States. Environmental Protection Agency. *Contract Laboratory Program National functional guidelines for Inorganic Data Review.* EPA 540/R-94/013, 1994.

United States. Environmental Protection Agency. *National Drinking Water Regulations. Code of Federal Regulations*, Chapter 40, Part 141 and 143, 1997.

Wood, W.W., and W.H. Low. *Solute Geochemistry of the Snake River Plain Regional Aquifer System, Idaho and Eastern Oregon*. U.S. Geological Survey Professional Paper 1408-D, 1989.

Chapter 6
Verification Water Monitoring Program

In 2001, the INEEL OP collected 40 replicate groundwater and wastewater samples with the DOE's primary contractor at the INEEL (BBWI), and the monitoring groups at ANL-W and NRF.

- Most of the results reported by the INEEL OP were comparable to those reported by BBWI, ANL-W, and NRF. The observed differences were generally attributable to sample heterogeneity or the use of different analytical methods.

Introduction

The objective of the INEEL OP's verification program is to verify and supplement the analytical data reported for wastewater and groundwater samples collected by BBWI and the monitoring groups at ANL-W and NRF. Sampling is limited to long-term monitoring programs such as those developed for CERCLA Records of Decision (RODs), Wastewater Land Application Permits (WLAP), and environmental surveillance. The sampling program was not designed to duplicate the DOE's extensive sampling network, but rather to collect a sufficient number of samples, typically about 10%, to provide an additional level of confidence in the analytical data reported by the DOE. During 2001, the INEEL OP collected 40 replicate samples at the 18 groundwater and 11 wastewater locations shown in **Figure 2-7** in **Chapter 2**. USGS-55 is a perched water well, the other groundwater wells sampled are in the Snake River Plain Aquifer. The analytical results are summarized in **Table 6-1.**

Because the samples are collected for various purposes (WLAP, CERCLA, surveillance), the analytes and analytical methods are variable. Therefore, the interprogram comparison is performed on a per sample basis; that is, each analytical result is compared directly to the result reported by the INEEL OP. The interprogram comparisons can be somewhat tenuous when there are small sample populations; but the program will likely expand as additional CERCLA post-ROD monitoring plans are developed.

Table 6-1. Range of concentrations reported for INEEL OP samples collected with ANL-W, BBWI, and NRF, 2001

Analyte	Range of Concentrations				Drinking Water Standard[a]
	Wastewater		Groundwater		
	Minimum	Maximum	Minimum	Maximum	
Common Ions (mg/L)					
Alkalinity (as CaCO3)	76	604	97	209	None
Calcium	7.5	1710	26.3	114	None
Chloride	27.1	17408	3.1	216	SMCL=250
Fluoride	0.19	0.75	0.23	0.6	SMCL=2, MCL = 4
Magnesium	0.9	536	11.3	28	None
Potassium	1.9	58	2.4	5.4	None
Silica	6.4	56.7	19.7	35.7	None
Sodium	24	9000	8	83	None
Sulfate	19.3	398	15	168	SMCL=250
Total Dissolved Solids	293	30100	175	760	SMCL=500
Total Suspended Solids	<1	608	<1	61	None
Nutrients (mg/L)					
Ammonia (as N)	0.005	3.1	<0.005	0.006	None
Nitrite (as N)	<0.005	0.007	<0.005	<0.005	1
Nitrite + Nitrate (as N)	<0.005	5.88	0.346	3.41	10
Phosphate (as P)	0.022	6.99	0.008	0.345	None
Total Kjeldahl N (TKN)	0.08	46.8	<0.05	0.13	None
Trace Metals (μg/L)					
Aluminum	<50	896	<50	2050	SMCL=50-200
Antimony	<5	<25	<5	<5	6
Arsenic	<10	<25	<5	<10	10[f]
Barium	32	3650	21	246	2000
Beryllium	<1	<1	<1	<1	4
Cadmium	<1	<1	<1	<1	5
Chromium	<5	<105	<5	146	100
Cobalt	<5	<50	<5	<5	None
Copper	<10	<100	<10	<10	SMCL=1000, AL = 1300
Iron	<10	1680	<10	3900	SMCL=300
Lead	<5	<5	<5	12	AL=15
Manganese	<1	410	<1	64	SMCL=50
Mercury	<0.5	<0.5	<0.5	<0.5	2
Nickel	<5	<50	<5	8	None
Selenium	<5	<50	<5	<10	50

Table 6-1 continued. Range of concentrations reported for INEEL OP samples collected with ANL-W, BBWI, and NRF, 2001

Analyte	Range of Concentrations				Drinking Water Standard[a]
	Wastewater		Groundwater		
	Minimum	Maximum	Minimum	Maximum	
Silver	<1	8	<1	<1	SMCL = 100
Thallium	<1.5	<7.5	<1.5	<1.5	2
Vanadium	<100	<100	<100	<100	None
Zinc	<5	190	<5	2020	SMCL=5000
Volatile Organic Compounds (μg/L)[b]					
Carbon Tetrachloride	NR[c]	NR	<0.5	1.35	5
Radionuclides (pCi/L)[d]					
Americium-241	NR	NR	<MDC	<MDC	15
Cesium-137	<MDC	<MDC	<MDC	<MDC	200
Cobalt-60	<MDC	<MDC	<MDC	<MDC	100
Gross Alpha (as Am-241)	<MDC	3.9±2.4	<MDC	4.8±1.9	15
Gross Beta (as Cs-137)	<MDC	9.2±2.8	<MDC	86.9±2.8	200[e]
Neptunium-237	NR	NR	<MDC	<MDC	15
Strontium-90	<MDC	<MDC	<MDC	35.4±6.5	8
Plutonium-238	NR	NR	<MDC	<MDC	15
Plutonium-239/240	NR	NR	<MDC	<MDC	15
Plutonium-241	NR	NR	<MDC	<MDC	15
Technetium-99	NR	NR	<MDC	1.1±0.6	900[e]
Tritium	<MDC	<MDC	<MDC	35600±400	20000
Uranium-234	NR	NR	1.22±0.28	1.22±0.28	20 μg/L
Uranium-235	NR	NR	<MDC	<MDC	20 μg/L
Uranium-238	NR	NR	0.06±0.019	0.06±0.019	20 μg/L

a. Maximum contaminant level (MCL) unless otherwise noted. AL=Action Level from Lead and Copper Rule; SMCL=Secondary maximum contaminant level.
b. List limited to analytes detected in at least one sample. See Table 6-3 for a complete list of analytes.
c. NR=Not requested
d. Counting uncertainty reported at 2s.
e. For beta-emitters, the maximum contaminant level is expressed as a cumulative annual dose of 4 millirem/year; for cesium-137, this is equivalent to 200 pCi/L, if cesium-137 were the only radionuclide detected.
f. Compliance data is 1/23/06.

Comparison of Nonradiological Results

For non-radionuclide analyses, if the reported concentration of the analyte exceeded the detection limit by a factor of five or more in both samples, the relative percent difference (RPD) between the two analytical results was calculated using the following equation:

$$RPD = \frac{|C_1 - C_2|}{(C_1 + C_2)/2} \times 100$$

where:
C_1 = reported concentration of the analyte in the sample collected by the INEEL OP
C_2 = reported concentration of the analyte in the sample collected by the contractor

An RPD of ≤30% is considered acceptable for inorganics, and an RPD of ≤40% is acceptable for organic compounds. For replicate samples in which one, or both, of the results reported for a particular analyte are less than five times the detection limit, the results are considered comparable if the two results differ by an amount equal to or less than twice the detection limit. These comparison criteria are based primarily on the degree of accuracy the IBL and the EPA requires for internal matrix spikes (EPA, 1994; 1994a). The INEEL OP has adopted these standards as guidelines. If less than 90% of the replicates for a particular analyte meet the desired level of accuracy, the results are investigated further. For 2001, seven inorganic analytes failed to meet these criteria and required additional evaluation. (**Table 6-2)**

Nearly all of the replicate sample pairs for barium and total suspended solids that failed the comparison criteria were wastewater samples. The differences in the analytical results for these wastewater samples are likely due to sample heterogeneity, which is of particular concern in unfiltered samples. Several of the replicate pairs that failed the comparison criteria for total dissolved solids and nitrate + nitrite were groundwater samples, indicating that sample heterogeneity can be significant in that media, especially in unfiltered samples.

Four of the five replicate pairs for total kjeldahl nitrogen (TKN) that failed the comparison criteria were wastewater samples. The TKN results were discussed with the representatives from the IBL, who suspected that the differences were due to variation in the amount of total suspended solids in the samples.

Six of the eight replicate pairs for iron that failed the comparison criteria were wastewater samples and two were groundwater samples. Because the analyses are performed on unfiltered samples, differences in the amount of particulate iron (e.g., rust and basalt fragments) in the replicate samples can cause significant differences in the reported iron concentration. For example, the INEEL OP collected a duplicate sample at well NRF-6 and the reported iron concentrations in the first sample and the duplicate were 320 μg/L and 990 μg/L, respectively.

Ammonia failed the comparison criteria, but the sample population was small (five) and only one replicate pair for ammonia did not meet the criteria.

Table 6-2. Comparison of concentrations of common ions, nutrients, and trace metals reported for replicate samples collected with ANL-W, BBWI, and NRF, 2001

Analyte	Number of replicate sample pairs	Number of pairs where analyte detected in both samples	Number of replicate pairs where relative percent difference ≤ 30%, or where results are within twice the detection limit	Percent of replicate samples with comparable results
Common Ions				
Alkalinity (as $CaCO_3$)	4	4	4	100
Calcium	15	15	15	100
Chloride	23	23	21	91
Fluoride	14	10	14	100
Magnesium	15	15	15	100
Potassium	15	11	15	100
Silica	0	NA	NA	NA
Sodium	29	29	28	97
Sulfate	24	24	22	92
Total Dissolved Solids	15	15	12	80
Total Suspended Solids	11	9	6	55
Nutrients				
Ammonia (as N)	5	2	4	80
Nitrite (as N)	10	0	10	100
Nitrite+Nitrate (as N)	31	26	25	81
Phosphate (as P)	21	15	19	90
Total Kjeldahl N (TKN)	20	11	15	75
Trace Metals				
Aluminum	23	5	22	96
Antimony	22	1	22	100
Arsenic	31	0	31	100
Barium	28	28	23	82
Beryllium	22	0	22	100
Cadmium	31	0	31	100
Chromium	35	24	35	100
Cobalt	9	0	9	100
Copper	25	3	25	100
Iron	28	12	20	71
Lead	29	2	27	93
Manganese	27	9	25	93
Mercury	33	0	33	100
Nickel	22	1	22	100
Selenium	30	0	30	100
Silver	29	3	29	100
Thallium	22	0	22	100
Vanadium	9	0	9	100
Zinc	23	9	23	100

All the volatile organic compounds (VOCs) met the criteria of ≥90% comparable results (**Table 6-3**).

Comparison of Radiological Analyses

Unlike the nonradioactive constituents for which analytical error is not reported, the analytical (counting) error must be considered when evaluating radioactivity analyses. Therefore, the results reported for the replicate radionuclide analyses are considered to be comparable if either:

1) $|C_1-C_2| \leq 3(s_1^2+s_2^2)^{1/2}$
where:

C_1 = reported concentration of the analyte in the sample collected by the INEEL OP
C_2 = reported concentration of the analyte in the sample collected by the contractor
s_1 = sample standard deviation of the INEEL OP sample
s_2 = sample standard deviation of the contractor sample

or

2) the relative percent difference (RPD) was less than or equal to 20%.

The approach outlined above is used by the ISU EML to determine whether the results of its duplicate analyses are within control limits.

Table 6-3. Comparison of concentrations of volatile organic compounds reported for replicate samples collected with BBWI and NRF, 2001

Analyte	Number of replicate sample pairs	Number of pairs where analyte detected in both samples	Number of replicate pairs where relative percent difference ≤ 40%, or where results are within twice the detection limit	Percent of replicate samples with comparable results
Benzene	14	0	14	100
Bromobenzene	4	0	4	100
Bromochloromethane	4	0	4	100
Bromodichloromethane	10	0	10	100
Bromoform	14	0	14	100
Bromomethane	14	0	14	100
n-Butylbenzene	0	NA	NA	NA
sec-Butylbenzene	4	0	4	100
tert-Butylbenzene	4	0	4	100
Carbon tetrachloride	14	4	14	100
Chlorobenzene	14	0	14	100
Chloroethane	14	0	14	100
Chloroform	14	0	14	100
Chloromethane	14	0	14	100
2-Chlorotoluene	4	0	4	100
4-Chlorotoluene	4	0	4	100
Dibromochloromethane	14	0	14	100
1,2-Dibromo-3-chloropropane	6	0	6	100
1,2-Dibromoethane	6	0	6	100

Table 6-3 continued. Comparison of concentrations of volatile organic compounds reported for replicate samples collected with BBWI and NRF, 2001

Analyte	Number of replicate sample pairs	Number of pairs where analyte detected in both samples	Number of replicate pairs where relative percent difference ≤ 40%, or where results are within twice the detection limit	Percent of replicate samples with comparable results
Dibromomethane	4	0	4	100
1,2-Dichlorobenzene	4	0	4	100
1,3-Dichlorobenzene	4	0	4	100
1,4-Dichlorobenzene	4	0	4	100
Dichlorodifluoromethane	6	0	6	100
1,1-Dichloroethane	14	0	14	100
1,2-Dichloroethane	14	0	14	100
1,1-Dichloroethene	14	0	14	100
cis-1,2-Dichloroethene	6	0	6	100
trans-1,2-Dichloroethene	14	0	14	100
1,2-Dichloropropane	14	0	14	100
1,3-Dichloropropane	4	0	4	100
2,2-Dichloropropane	4	0	4	100
1,1-Dichloropropene	4	0	4	100
cis-1,3-Dichloropropene	14	0	14	100
trans-1,3-Dichloropropene	6	0	6	100
Ethylbenzene	14	0	14	100
Hexachlorobutadiene	4	0	4	100
Isopropylbenzene	4	0	4	100
p-Isopropyltoluene	4	0	4	100
Methylene chloride	14	0	14	100
Naphthalene	4	0	4	100
n-Propylbenzene	4	0	4	100
Styrene	6	0	6	100
1,1,1,2-Tetrachloroethane	6	0	6	100
1,1,2,2-Tetrachloroethane	14	0	14	100
Tetrachloroethene	14	0	14	100
Toluene	14	0	14	100
1,2,3-Trichlorobenzene	4	0	4	100
1,2,4-Trichlorobenzene	4	0	4	100
1,1,1-Trichloroethane	14	0	14	100
1,1,2-Trichloroethane	14	0	14	100
Trichloroethene	14	0	14	100
Trichlorofluoromethane	6	0	6	100
1,2,3-Tricholopropane	6	0	6	100
1,2,4-Trimethylbenzene	4	0	4	100
1,3,5-Trimethylbenzene	4	0	4	100
Vinyl chloride	14	0	14	100
Xylenes (total)	6	0	6	100

As shown in **Table 6-4**, uranium 238 and gross beta screening results were the only radiological analyses that did not meet the comparison criteria. Only one sample pair was available for uranium isotopes and neptunium-237.

The INEEL OP reported a lower gross beta concentration than BBWI and NRF in all but one of the replicate pairs. This bias has been noted in the past but the cause has not yet been determined with any certainty. Differences in the size of detectors, window density thickness, calibration isotopes, and development of mass absorption curves may all be contributing factors.

Table 6-4. Comparison of radionuclide concentrations reported for replicate samples collected with ANL-W, BBWI, and NRF, 2001

Analyte	Number of replicate sample pairs	Number of pairs where analyte detected in both samples	Number of replicate pairs where relative percent difference ≤ 20%, or where results are within three times the weighted counting error	Percent of replicate samples with comparable results
Americium-241	9	0	9	100
Cesium-137	25	0	25	100
Gross Alpha (as Am-241)	22	5	20	91
Gross Beta (as Cs-137)	22	14	16	73
Neptunium-237	1	0	1	100
Plutonium-238	9	0	9	100
Plutonium-239/240	9	0	9	100
Plutonium-241	0	NA	NA	NA
Strontium-90	8	2	8	100
Technetium-99	4	0	4	100
Tritium	21	7	19	90
Uranium-234	1	1	1	100
Uranium-235	1	0	1	100
Uranium-238	1	1	0	0

References

EPA (U.S. Environmental Protection Agency). *USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review*. EPA 540/R-94/013, 1994.

EPA (U.S. Environmental Protection Agency). *USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review*. EPA 540/R-94/012, 1994a.

Chapter 7
External Radiation Monitoring

Major Findings and Developments

Ambient penetrating exposure measurements performed during 2001 were consistent with historical background measurements. Redundancy in data collection and use of passive radiation detectors provided adequate cumulative average exposure rates at each gamma monitoring location.

- No offsite environmental impacts from INEEL operations were detected with environmental ambient gamma radiation exposure-rate measurements.
- Inter-program comparisons of different surveillance program results show good agreement. Discrepancies are attributable to differences in monitoring schedules and different penetrating radiation measurement techniques.

Primary Penetrating Radiation Monitoring Results and Trends

The INEEL OP monitors ambient exposure rates measured in real time using a network of high-pressure ion chambers (HPIC) and electret ion chambers (EIC). While each of the detection systems measures penetrating radiation, the HPIC data measures real-time exposure rates that can be used to calculate hourly, daily, weekly, monthly, quarterly, and annual average exposure rates. EIC data reflects cumulative dose for the period of time during which the device is deployed.

Penetrating radiation exposure measurements were within levels typically accepted as "background," including cosmic radiation and gamma radiation emitted from radionuclides distributed in soil and rock. Penetrating radiation measurements at these locations are expected to range from 9 to 15 μR/h. Exposure rates are estimated using cosmic ray response reported by the HPIC manufacturer and using exposure rate dose coefficients provided in NCRP 94 for radionuclide concentrations in local soil.

Routine Penetrating Radiation Measurements

INEEL OP routinely monitors penetrating radiation at 15 locations. Of these locations, INEEL OP operates 11 HPICs and the Shoshone-Bannock tribes operate a HPIC at the Fort Hall Community Monitoring Station. No significant impacts to the environment were identified through the use of the HPIC radiation monitoring network. Multiple EICs are deployed at each of these same locations. Average exposure rates observed using EICs ranged from 13.0 to 22.8 μR/h and average exposure rates observed using HPICs ranged from 10.2 to 13.6 μR/h as shown in **Figure 7-1** and **Table 7-1.** Due to differences in construction, the EIC is somewhat more responsive to low-energy photons and exposure rates are typically 30 to 40 percent greater than those observed using the HPIC. Additionally, a systematic negative bias was observed during the HPIC annual source checks, the cause of this bias is being investigated.

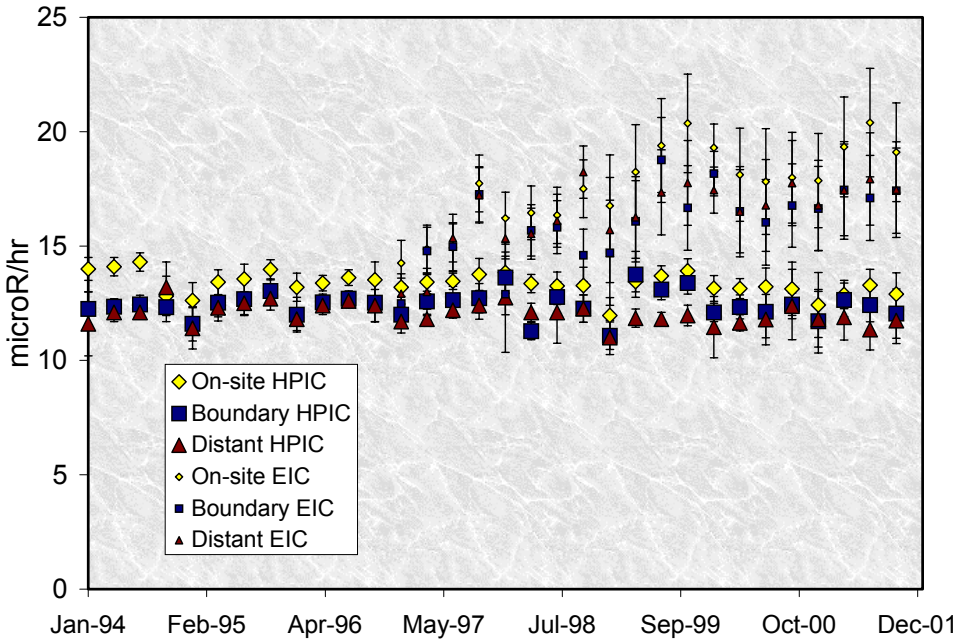

Figure 7-1. Average quarterly exposure rates observed by INEEL OP since January 1994 using high-pressure ion chambers and since January 1997 using electret ion chambers.

Table 7-1. Average exposure rates observed at routine gamma monitoring locations using electret ion chambers

Location	1st Quarter 2001 (μR/hour)	2nd Quarter 2001 (μR/hour)	3rd Quarter 2001 (μR/hour)	4th Quarter 2001 (μR/hour)
Mud Lake/Terreton	15.4 ± 1.8 [a]	17.9 ± 2.0	15.7 ± 1.9	16.5 ± 1.8
Monteview	17.6 ± 1.9	16.4 ± 2.0	16.3 ± 1.9	17.7 ± 1.9
Rest Area	18.0± 1.9	19.3 ± 2.1	17.8 ± 1.9	18.4 ± 1.9
Atomic City	16.3± 1.9	18.4 ± 2.0	16.6 ± 1.9	18.2 ± 1.9
Howe Meteorological Tower	16.7± 1.9	16.1 ± 2.0	16.3 ± 1.9	19.8 ± 1.8
Idaho Falls	13.0 ± 1.8	14.0 ± 1.9	15.3 ± 1.8	15.9 ± 1.8
EFS	17.5 ± 2.3	19.2 ± 2.5	21.0 ± 2.5	20.4 ± 2.4
Van Buren	18.3 ± 2.3	21.2 ± 2.6	22.6 ± 3.6	20.0 ± 2.4
Craters	13.9 ± 2.2	16.7 ± 2.4	15.7 ± 2.2	16.0 ± 2.2
Base of Howe	17.0 ± 1.9	16.2 ± 2.0	20.7 ± 2.0	15.7 ± 1.6
Big Southern Butte	15.4 ± 1.6	18.0 ± 2.2	17.9 ± 1.9	19.4 ± 2.1
Rover	17.2 ± 2.1	17.9 ± 2.0	20.1 ± 2.0	20.1 ± 2.1
Sand Dunes	17.1 ± 1.9	19.8 ± 2.1	19.9 ± 2.4	19.2 ± 1.9
Main Gate	19.9 ± 2.0	19.0 ± 2.0	20.7 ± 2.1	19.8 ± 1.9
Ft Hall	19.0 ± 1.9	19.8 ± 2.1	22.8 ± 2.1	22.5 ± 2.0

[a] Corresponds to a 2-sigma propagated uncertainty.

Table 7–2. Average exposure rates observed using high-pressure ion chambers

Location	1st Quarter 2001 (μR/hour)	2nd Quarter 2001 (μR/hour)	3rd Quarter 2001 (μR/hour)	4th Quarter 2001 (μR/hour)
Atomic City	12.0 ± 1.6 [a]	12.7 ± 0.7	12.7 ± 0.8	12.6 ± 0.9
Base of Howe	11.4 ± 1.5	12.5 ± 0.6	12.5 ± 0.6	12.2 ± 0.9
Big Southern Butte	11.4 ± 2.2	13.4 ± 0.8	13.6 ± 0.7	13.1 ± 2.1
Ft Hall	11.7 ± 1.5	12.5 ± 1.2	12.5 ± 1.3	11.8 ± 1.2
Howe Met. Tower	12.4 ± 1.6	12.1 ± 0.8	12.2 ± 0.7	12.0 ± 0.8
Idaho Falls	10.4 ± 1.3	10.7 ± 0.6	10.5 ± 0.5	10.9 ± 0.5
Main Gate	13.4 ± 1.3	13.6 ± 0.6	13.6 ± 0.8	13.3 ± 1.0
Monteview	10.2 ± 0.9	11.7 ± 0.7	11.8 ± 0.7	11.5 ± 0.8
Mud Lake/Terreton	11.6 ± 1.5	12.3 ± 0.8	12.1 ± 0.7	12.5 ± 0.6
Rest Area	11.9 ± 1.8	13.0 ± 0.6	13.1 ± 0.7	12.7 ± 1.1
Rover	12.7 ± 1.3	13.3 ± 0.7	13.4 ± 0.7	13.5 ± 0.8
Sand Dunes	12.7 ± 1.2	12.8 ± 0.7	12.9 ± 0.6	12.9 ± 0.9

[a] Corresponds to one sample standard deviation of the data set collected during the calendar quarter.

Supplemental Radiation Measurements

INEEL OP deploys EICs at 77 additional locations to supplement the radiation monitoring network. Some of the EICs are deployed at radiation monitoring locations maintained by BBWI and ESER for verification purposes. EICs are also deployed at several locations on the INEEL, along the INEEL boundary, and at distant locations to provide additional technical information for emergency response efforts in the event of an accidental radiological release associated with INEEL operations. Supplemental radiation measurements ranged from 10.9 to 34.3 μR/h with an average exposure rate of 19.6 μR/h, median exposure rate of 19.5 μR/h, and a sample standard deviation of 3.41 μR/h. These measurements were similar to those observed in historical EIC measurements.

During 2001, the penetrating radiation monitoring program experienced equipment problems. An updated data logging system developed software and hardware problems that were difficult to resolve. These problems should be resolved during 2002 with changes in data logging hardware and polling software.

Comparison of External Radiation Monitoring Results Reported by DOE Contractor

Penetrating radiation measurements demonstrated good agreement between the three environmental radiation exposure surveillance programs monitoring on and around the INEEL. Descriptive statistics for comparison between INEEL OP exposure rate measurements using EICs and ESER and BBWI TLDs are shown in **Table 7–3**.

Table 7-3. Descriptive statistics for comparison between exposure measurements for INEEL OP, ESER, and BBWI

	OP (mR)	BBWI (mR)
Average:	84.1	66.0
Median:	84.5	66.0
Standard Deviation:	15.1	6.5
Minimum:	58.8	52.0
Maximum:	133.0	84.0
	OP (mR)	**ESER (mR)**
Average:	73.9	65.2
Median:	73.1	66.1
Standard Deviation:	8.5	5.5
Minimum:	60.1	56.7
Maximum:	94.0	75.1

In 2001, BBWI and ESER used TLDs to determine cumulative exposures over a period of time. BBWI and ESER deployed lithium fluoride (LiF) TLDs, that were collected on a six-month cycle, and INEEL OP deployed EICs that were collected on three-month and six-month cycles depending upon where the EICs were deployed.

Measurements are considered in agreement if the reported values agree within 3-sigma measurement uncertainty or 20-percent relative difference. A summary of this comparison is shown in **Table 7-4**.

Table 7–4. Summary of comparison between INEEL OP, ESER, and BBWI gamma exposure rate measurements

	OP vs. BBWI	OP vs. ESER
Average relative percent difference:	-11.6%	-6.2%
Percent in agreement (3-sigma):	94.2%	100.0%
Percent in agreement (relative difference):	97.1%	100%
Number of samples:	69	20

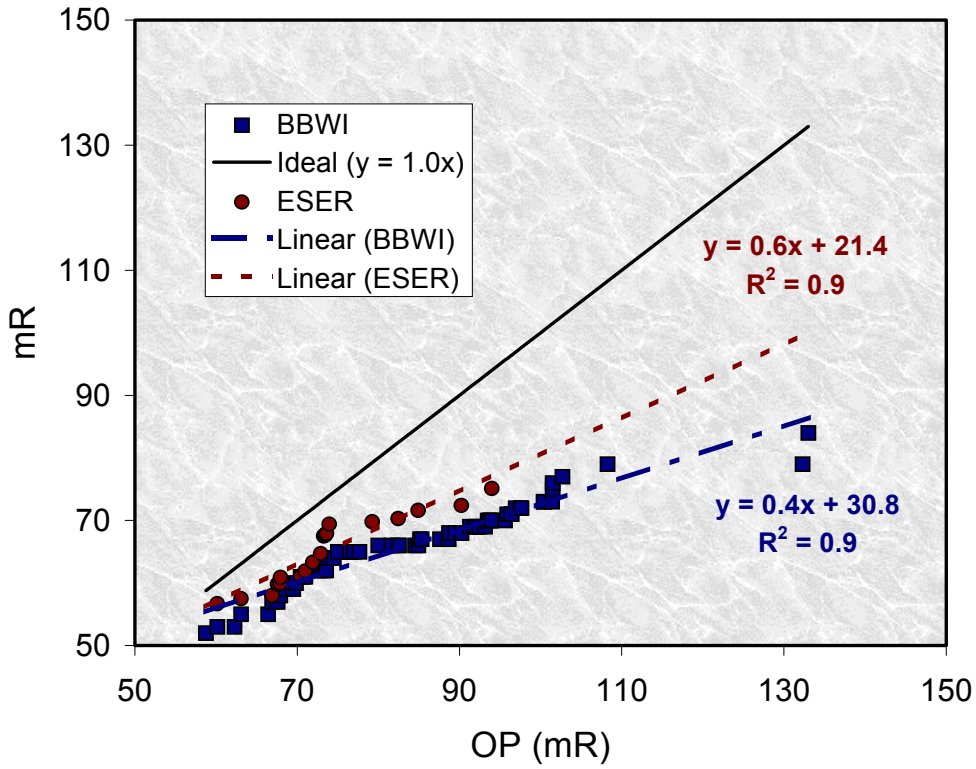

Figure 7-2. Quantile-Quantile plot of co-located INEEL OP EICs and BBWI and ESER TLDs comparing 2001 radiation exposure measurements

No comparisons of real-time HPIC data were made due to the lack of co-located HPICs. Although the gamma results reported by the INEEL OP, BBWI, and ESER in 2001 fell within levels accepted as background, direct comparisons of the programs' results provide qualitative correlation between the data sets. **Figure 7-2** shows a Quantile-Quantile plot of co-located INEEL OP EICs and BBWI and ESER TLDs comparing 2001 radiation exposure measurements. The comparison of results illustrated in **Figure 7-2** reflects inter-program variations in monitoring schedules and monitoring techniques. Deployment periods used by INEEL OP did not precisely match the deployment periods used by either BBWI or ESER. INEEL OP deploys passive EICs at the beginning of each calendar quarter for the duration of that calendar quarter. BBWI and ESER deploy TLDs for 6-month deployment periods from November to May and May to November.

Conclusion

Environmental monitoring of penetrating radiation indicated no impact to the environment as a result of INEEL operations during 2001. Overall, the DOE-ID environmental radiation monitoring results are consistent with INEEL OP environmental radiation monitoring results. Slight variations were expected due to differences in monitoring periods and differences in monitoring methods. As experienced when comparing HPIC measurements to EIC measurements, the EIC typically exhibits greater sensitivity to low energy x-rays and thus, greater response. The same is likely true for the discrepancy between INEEL OP EIC measurements and TLD measurements made by ESER and BBWI.

References:

National Council on Radiation Protection and Measurements, *Exposure of the Population in the United States and Canada from Natural Background Radiation*, NCRP Report Number 94, 1987.

Reuter-Stokes. *RSS-1013 PIC Environmental Radiation Monitoring Station Operational Manual*. Version 1.4, May 1993.

Chapter 8
Quality Assurance/Quality Control

INEEL Oversight Program Environmental Surveillance Program QA/QC for Measurements

This section summarizes the QA/QC samples (spikes, blanks, and duplicate), submitted to the IBL for nonradiological analyses and to the ISU EML for radiological analyses for 2001. In addition, this section includes any corrective actions that were identified or implemented for the ESP.

All analyses and QA measures in the analytical laboratories are performed in accordance with approved written procedures maintained by each respective analytical laboratory. Sample collection is performed in accordance with written procedures maintained by the INEEL OP.

The ISU EML reported a suspected laboratory tritium contamination problem for both third and fourth quarters of 2001. Subsequently, many of the water and precipitation sample results were qualified as estimates or rejected based on this contamination issue. The EML also reported cesium-137 contamination issues with one of their detectors. This contamination affected three PM_{10} composite samples that were rejected and recounted after the detector had been decontaminated.

The INEEL OP participated in several external QA/QC programs: State of Washington's Quality Assurance Task Force (QATF), the Mixed Analyte Performance Evaluation Program (MAPEP), 12^{th} International Intercomparison of Environmental Dosimeters, and a cooperative preparation of spiked samples with the USGS and BBWI for laboratory comparison purposes.

Spike and duplicate sample results submitted by the INEEL OP do not indicate any laboratory bias or problems. However, several gross beta screening results for blank PM_{10} samples indicate a slight negative bias.

Corrective actions that were identified and initiated are changes in sample volume submitted to the EML and additional laboratory precautions to prevent future tritium contamination.

Quality Assurance Program

The measurement of any physical quantity is subject to uncertainty from errors that may be introduced during sample collection, measurement, calibration, and the reading and reporting of results as well as natural variation in the quantity measured. While the sum of these inaccuracies cannot be quantified for each analytical result, a quality assurance program can evaluate the overall quality of a data set and possibly identify and address errors or inaccuracies.

Analytical results for spikes, duplicates, and blanks are used to assess the precision, accuracy, and representative nature of results from analyzing laboratories. During 2001, the INEEL OP submitted 348 QA/QC samples for various radiological and nonradiological analyses. Detailed data tables can be found in each of the quarterly reports for the sampling year 2001.

Blank Samples

Blank samples have negligible, acceptably low, or not measurable amounts of the analyte(s) of interest in them. They are designed to determine if analyses will provide a "zero" result when no contaminant is expected to be present, and therefore monitor any bias that may have been introduced during sample collection, storage, shipment, and analysis.

Gross Alpha and Beta Screening

During 2001, the INEEL OP submitted 62 blank samples for gross alpha and beta screening. The blank samples consisted of PM_{10} filters and water samples. Ninety-six percent of the blank PM_{10} filters submitted for gross alpha analyses were within 2 standard deviations of a "zero" result.

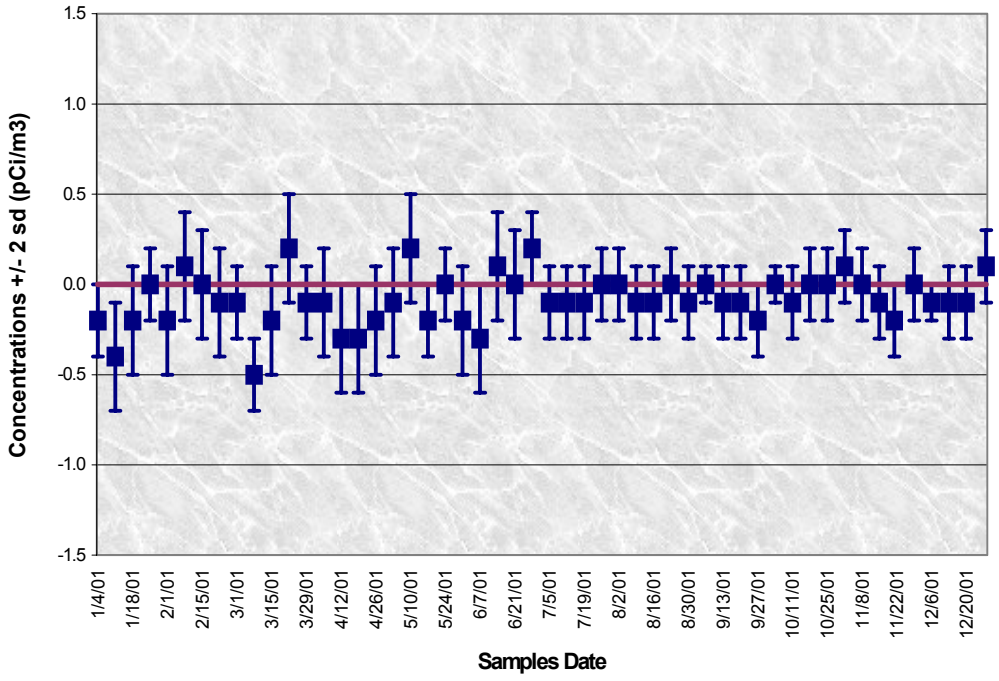

Figure 8-1. Blank PM_{10} alpha

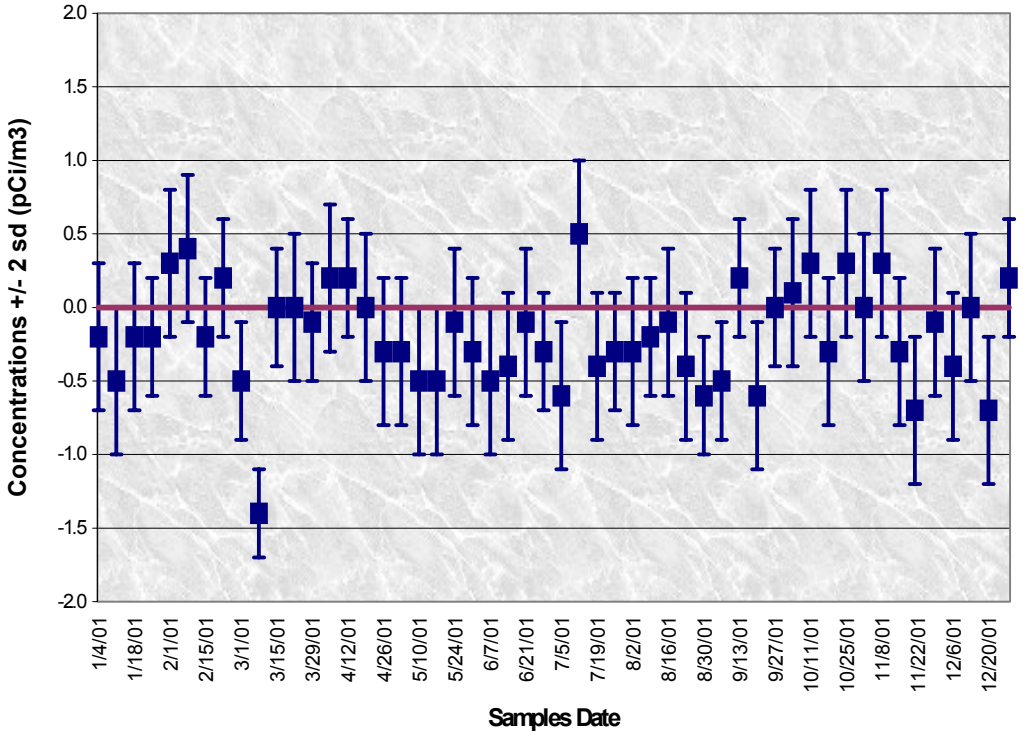

Figure 8-2. Blank PM_{10} beta

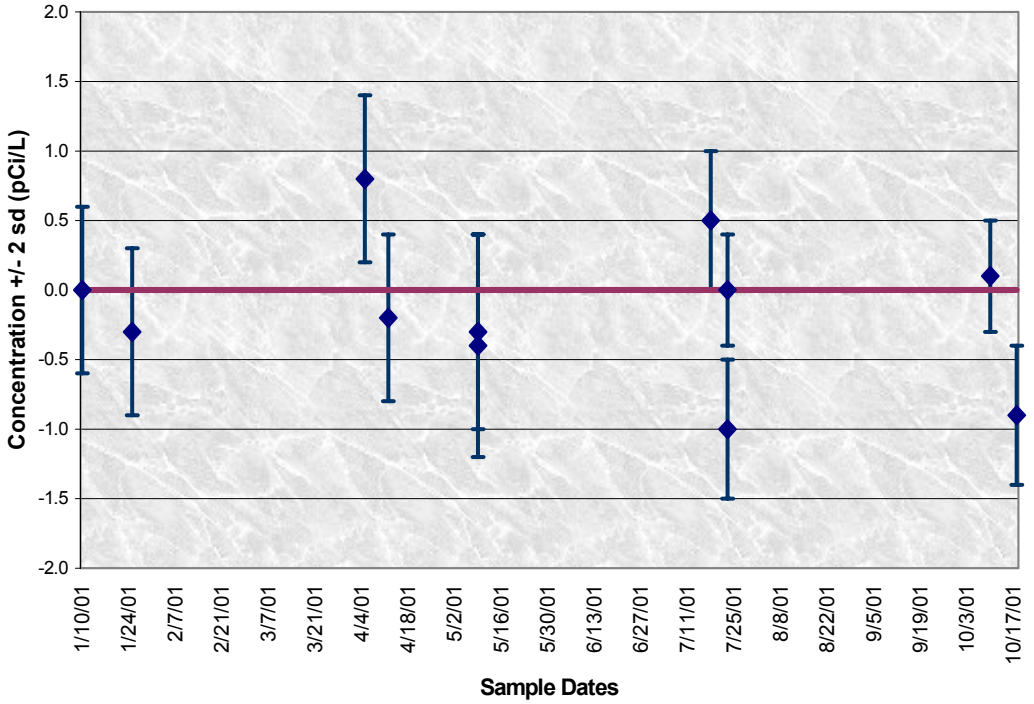

Figure 8-3. Blank water alpha

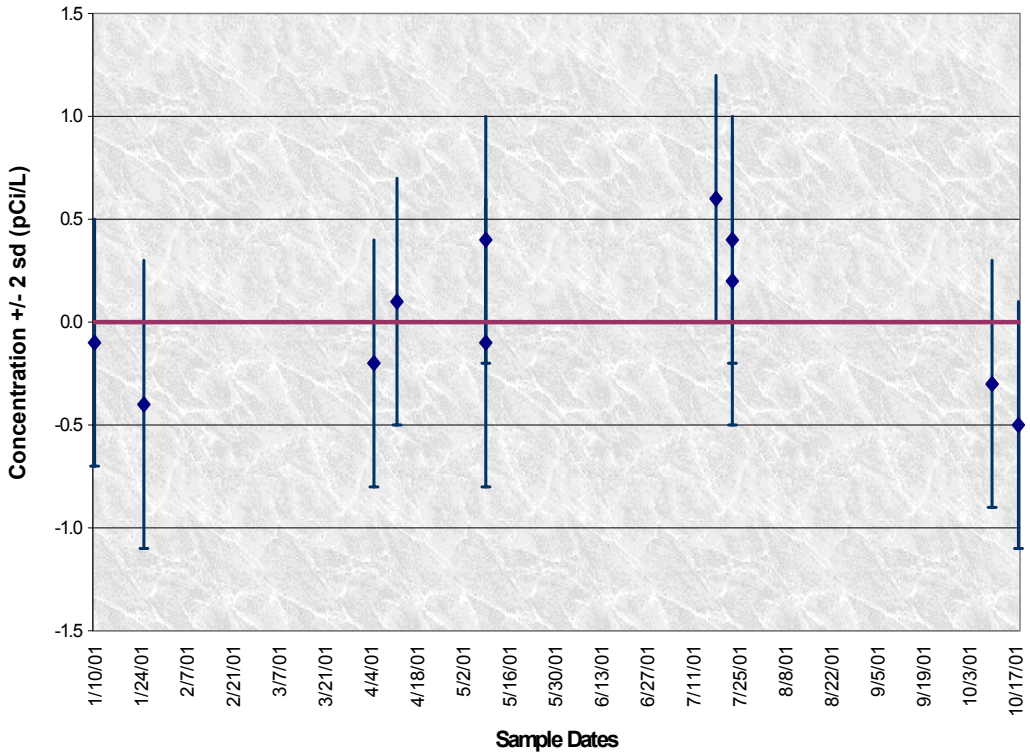

Figure 8-4. Blank water beta.

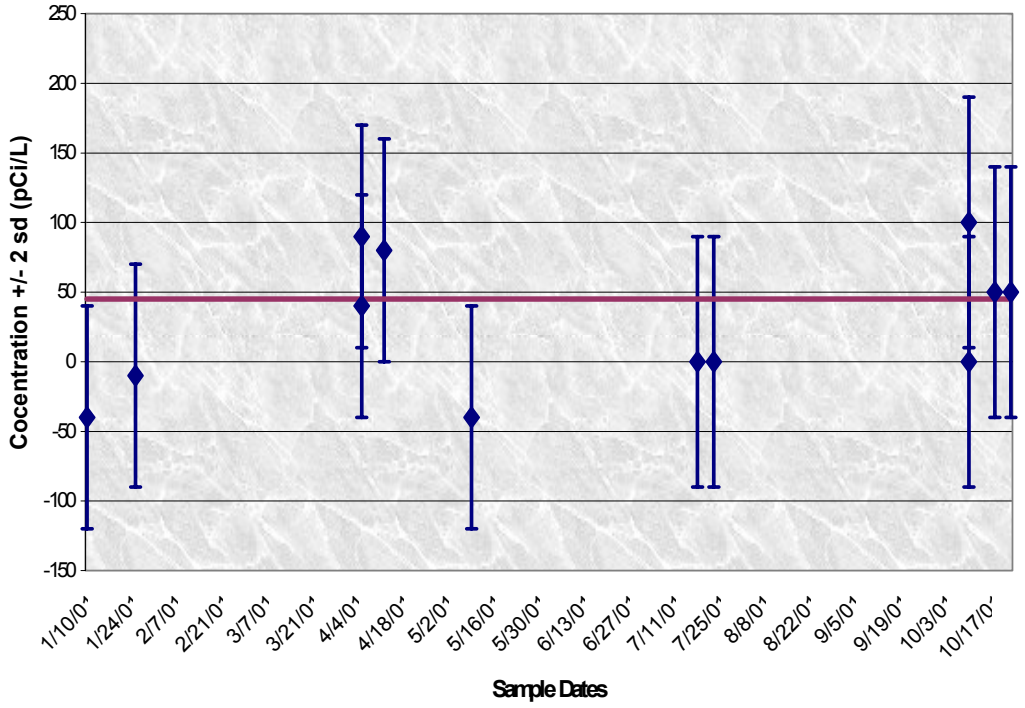

Figure 8-5. Blank water H3.

Eighty-four percent of the blank PM_{10} filters submitted for gross beta analyses were within 2 standard deviations of a "zero" result. All of those results that did not meet the criteria were less than zero, indicating a slight negative bias.

For blank water samples, 82% of the gross alpha screening results were within 2 standard deviations of the "zero" result, and 100% of the gross beta screening results were within 2 standard deviations of the "zero" result.

Gamma Spectroscopy

During 2001, the INEEL OP submitted 14 blank samples for gamma spectroscopy analysis. The blank samples consisted of PM_{10} filter composites and water samples. For 2001, all of the blank samples submitted for gamma spectroscopy analysis were within 2 standard deviations of the "zero" result.

Tritium Analysis

During 2001, the INEEL OP submitted 12 blank water samples for tritium analysis. Natural background tritium levels in water are on average 45 pCi/L. This value is considered the "zero" result. Eight-three percent of the blank water samples submitted for tritium analysis were within 2 standard deviations of 45 pCi/L.

Nonradiological Analyses

All the blank samples submitted for metals, common ion, and nutrient analyses were less than the detection limit.

Spike Results

Spikes are samples to which known concentrations of specific analytes have been added. One indicator of agreement is the difference between the known concentration in the sample and the measured concentration, expressed as a relative percent difference. This quantity is calculated and averaged to give an average bias. The standard deviation of the differences can be used as an indicator of the overall precision of the dataset.

During 2001, the INEEL OP submitted spikes for various radiological and nonradiological analyses. Laboratory results for all of the spiked samples submitted as part of the routine environmental surveillance program for the year 2001 were acceptable, producing percent recoveries ranging from 97% to 120% for radiochemical analyses.

Electret Ion Chambers

To verify EIC response, INEEL OP has EICs irradiated with known and "blind" gamma

exposures. For quality assurance (QA) purposes, ISU EML conducts QA irradiations to a known exposure of 30 mR and a "blind" exposure ranging from 20 to 50 mR ("blind" in the context that INEEL OP does not know the exposure received until after the analysis is performed). EIC response using the factory E-PERM™ calibration factors is compared directly with the exposure received from the NIST traceable cesium-137 source used by ISU EML for these irradiations. EIC response is considered acceptable if each irradiated EIC agrees within 10% or within 3 standard deviations. Irradiation results for 2001 are shown in **Table 8-1** and **Figure 8-6** shows a graphic representation of EIC response with exposure received.

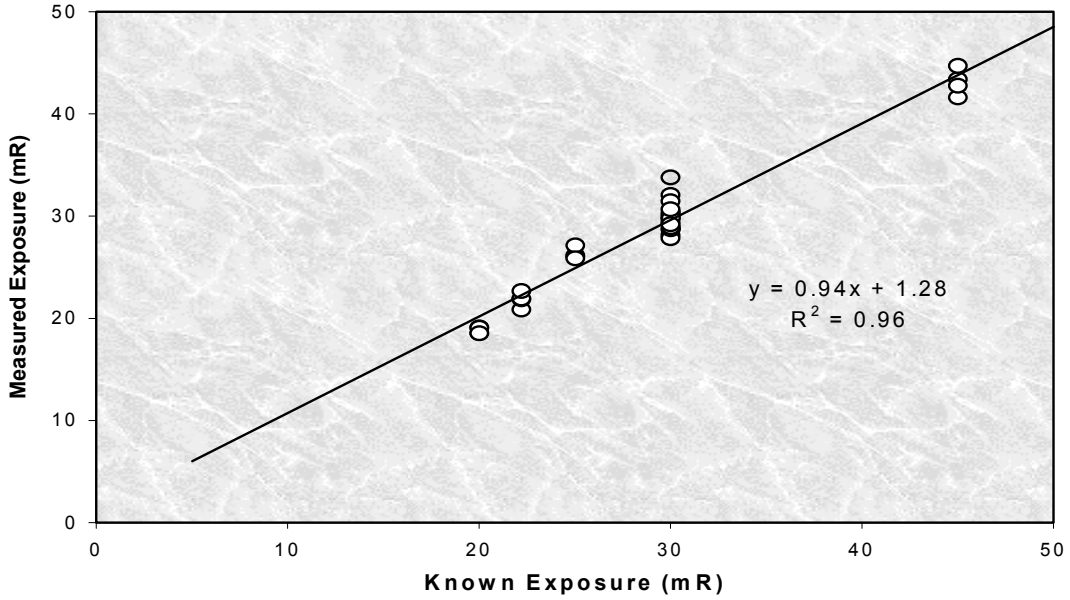

Figure 8-6. Internal QA irradiation results of EICs conducted in 2001. Electret ion chambers were irradiated by ISU EML.

Table 8–1. Quality assurance irradiation summary of EICs conducted in 2001

	"Measured" Exposure (mR)	"Known" exposure (mR)	Relative Difference
1st Quarter 2001 ("known")	30.2 ± 2.5 [a]	30.0 ± 1.5 [b]	0.7%
1st Quarter 2001 ("blind")	18.8 ± 0.3	20.0 ± 1.0	-6.0%
2nd Quarter 2001 ("known")	29.2 ± 1.0	30.0 ± 1.5	-2.7%
2nd Quarter 2001 ("blind")	21.8 ± 0.7	22.2 ± 1.1	-1.8%
3rd Quarter 2001 ("known")	29.4 ± 0.8	30.0 ± 1.5	-1.9%
3rd Quarter 2001 ("blind")	43.1 ± 1.3	45.0 ± 2.3	-4.2%
4th Quarter 2001 ("known")	30.8 ± 1.2	30.0 ± 1.5	2.8%
4th Quarter 2001 ("blind")	26.3 ± 0.6	25.0 ± 1.3	5.0%
		Overall Relative Difference:	-1.0%

[a] Propagated 1-sigma measurement uncertainty
[b] Propagated 1-sigma measurement uncertainty of irradiation including source assay uncertainty and irradiation time and distance uncertainty

High-Pressure Ion Chambers

Annual source checks were conducted at each HPIC deployed as part of the penetrating radiation monitoring network. The source check involves the direct comparison of instrument response to a gamma source between the HPIC deployed in the field and a "mobile" HPIC calibrated by the manufacturer. The results of this source check are shown in **Table 8-2**. Variation in HPIC response between different generations of HPICs deployed by INEEL OP is being investigated. The relative positioning of the 10 μCi Cesium-137 source with respect to the chamber inside the protective housing may be responsible for the pronounced differences in instrument response.

Table 8–2. 2001 summary of HPIC source field checks

Location	Date Performed	Relative Difference with Respect to the Calibrated HPIC
Atomic City	8/9/01	-7.7%
Base of Howe	6/26/01	-8.7%
Big Lost River Rest Area	7/11/01	-7.4%
Big Southern Butte	6/26/01	-2.2%
Fort Hall CMS	8/8/01	-0.6%
Howe Met Tower	8/30/01	-8.5%
Idaho Falls	8/28/01	-7.9%
Main Gate	8/9/01	-5.2%
Monteview	8/22/01	-5.5%
Mud Lake	8/22/01	-8.6%
Rover	6/27/01	-6.9%
Sand Dunes Tower	8/17/01	-8.8%
Average Relative Difference:		**-6.5%**

Duplicate Results

Duplicate samples are collected in a manner such that the samples are thought to be essentially identical in composition and are used to assess analytical precision.

Radiological analyses

During 2001, the INEEL OP submitted 14 duplicate samples for radiological analyses. Unlike the nonradioactive constituents for which no analytical uncertainty is reported, the counting uncertainty must be considered when evaluating the reproducibility of radioactivity analyses.

The results reported for the duplicate sample sets were considered to be within control limits for precision if:

$$/R_1 - R_2/ \leq 3\ (s_1^2 + s_2^2)^{1/2}$$

where,
R_1 = concentration of analyte in the first sample
R_2 = concentration of analyte in the duplicate sample
S_1 = sample standard deviation of the first sample
S_2 = sample standard deviation of the duplicate sample
or,

The Relative Percent Difference (RPD) was less than or equal to 20%.

If less than 90% of the duplicate analyses meet these criteria, further evaluation is conducted to determine whether a corrective action is necessary.

The gross beta radioactivity in the duplicate sample sets for USGS-014 and USGS-112 was not within control limits. Tritium in the duplicate sample sets for Clear Spring and USGS-120 were not within control limits either. This could be a direct result of tritium contamination problems the laboratory is experiencing.

Nonradiological analyses

During 2001, the INEEL OP submitted 16 duplicate samples for various nonradiological analyses. If the reported concentration of the analyte exceeded the detection limit by a factor of five or more in a sample and corresponding duplicate, the laboratory precision was determined by calculating the RPD between the two analytical results using the following equation:

$$RPD = \frac{/R_1 - R_2/}{(R_1 + R_2)/2} \times 100$$

Where

R_1 = concentration of analyte in the first or primary sample
R_2 = concentration of analyte in the duplicate sample.

For duplicate sample sets in which one or both of the results reported for a particular analyte was less than five times the detection limit, the level of precision was considered acceptable if the two results differed by an amount equal to or less than the detection limit. If less than 90% of the duplicate sample sets for a particular analyte meet the desired level of precision, the results are discussed with the laboratory to determine whether a corrective action is required.

Duplicate samples for 2001 were within control limits.

External QA/QC

During 2001, the INEEL OP participated in several external QA/QC programs. Blind spikes, blanks, and duplicate samples are one way to test the proficiency of a measurement process. These programs included MAPEP, QATF, the 12th International Intercomparison of Environmental Dosimetry, and a cooperative preparation of spiked samples with the USGS and BBWI for laboratory comparison purposes.

Mixed Analyte Performance Evaluation Program (MAPEP)

MAPEP is an external spike program for radiological analyses that was initiated in 1998. Spiked samples, which had been prepared for MAPEP by DOE-RESL, were obtained and submitted blind with radiological samples. These spiked samples are designed to represent a "real world" sample matrix, and consist of a long list of analyses, both radiological and chemical. Results were compared on the basis of recovery or a calculated relative percent difference. The INEEL OP results were on average within 10% of DOE-RESL results. The results for americium-241 differed by almost 20%, however these results were obtained by gamma spectroscopy and not alpha spectroscopy. (**Tables 8-3** and **8-4**)

State of Washington's Quality Assurance Task Force (QATF)

The QATF is an external QA program that supplies at least one blind sample of varying matrixes per year to its participants. The participants are given a list of analytes to report concentrations for. The analytical results are submitted to the QATF before the QATF announces the average concentrations of activities in the sample. For 2001, the QATF provided a water sample to participants. INEEL OP results are presented in **Table 8-5**. All results fell within the laboratory acceptance criteria.

The 12th International Intercomparison of Environmental Dosimeters

The 12th International Intercomparison of Environmental Dosimeters was sponsored by DOE's EML. Participants in the intercomparison submit multiple environmental dosimeters to be exposed to various levels of ionizing radiation under environmental and laboratory conditions. Results obtained by the participants are then compared with the other participants as well as with expected or "known" dose values. In March 2001, the DOE EML published preliminary reference dose values for the intercomparison. INEEL OP results using EICs were submitted with the other participants of the inter-comparison and are shown in **Table 8-6**.

Table 8-3. MAPEP

	Sample Number	Sample Date 2001	^{54}Mn(pCi/L)		^{57}Co (pCi/L)		^{60}Co (pCi/L)		^{65}Zn (pCi/L)	
			Activity	2 SD	Activity	2 SD	Activity	2 SD	Activity	2 SD
Spike 1	012W191	05/24	2.33E+03	8.58E+01	4.46E+02	3.62E+01	5.87E+03	1.59E+02	9.07E+02	4.43E+01
Spike 2	012W192	05/24	2.34E+03	9.17 E+01	4.19E+02	5.18E+01	5.96E+03	1.75E+02	8.80E+02	5.01E+01
Spike 3	012W193	05/24	3.95E+01	3.15E+01	1.02E+03	4.42E+01	6.28E+01	5.97E+00	4.39E+01	9.72E+00
Known Concentration										
Spike 1	012W191	05/24	2.29E+03	2.00E+01	4.47E+02	6.00E+00	5.68E+03	1.10E+02	8.30E+02	1.00E+01
Spike 2	012W192	05/24	2.29E+03	2.00E+01	4.47E+02	6.00E+00	5.68E+03	1.10E+02	8.03E+02	1.00E+01
Spike 3	012W193	05/24	3.61E+01	1.20E+00	1.07E+03	3.00E+01	5.23E+01	1.70E+00	4.67E+01	1.50E+00
Percent Difference										
Spike 1	012W191	05/24	1.71%		-0.15%		3.43%		9.33%	
Spike 2	012W192	05/24	2.11%		-6.26%		5.01%		6.06%	
Spike 3	012W193	05/24	9.47%		-4.43%		20.14%		-5.95%	

Table 8-3 continued. MAPEP

	Sample Number	Sample Date 2001	^{134}Cs (pCi/L)		^{137}Cs (pCi/L)		^{241}Am (pCi/L)	
			Activity	2 SD	Activity	2 SD	Activity	2 SD
Spike 1	012W191	05/24	1.09E+03	3.28E+01	1.78E+03	7.77E+01	1.39E+01	6.10E+00
Spike 2	012W192	05/24	1.18E+03	4.14E+01	1.86E+03	8.07E+01	ND	ND
Spike 3	012W193	05/24	5.38E+03	1.50E+02	2.45E+03	1.02E+02	2.12E+01	3.00E+01
Known Concentration								
Spike 1	012W191	05/24	1.19E+03	1.60E+01	1.88E+03	2.00E+01	1.71E+01	1.70E-01
Spike 2	012W192	05/24	1.19E+03	1.60E+01	1.88E+03	2.00E+01	1.71E+01	1.70E-01
Spike 3	012W193	05/24	5.57E+03	1.80E+02	2.50E+03	8.00E+01	2.86E+01	9.00E-01
Percent Difference								
Spike 1	012W191	05/24	-7.93%		-5.59%		-18.91%	
Spike 2	012W192	05/24	-0.12%		-1.33%		ND	
Spike 3	012W193	05/24	-3.42%		-1.90%			

Table 8-4 MAPEP Plutonium

	Sample Number	Sample Date 2001	Plutonium-238 (pCi/L)		Plutonium 239-240(pCi/L)	
			Activity	2 SD	Activity	2 SD
Spike 4	012W194	05/24	5.58E+01	7.64E+00	4.68E+01	6.44E+00
Known Concentration			5.68E+01	1.80E+00	5.01E+01	1.60E+00
Percent Difference			-1.76%		-6.59%	

Table 8-5. Results for the blind samples from the state of Washington's Quality Assurance Task Force (QATF), 2001.

QATF Collection Date	QATF Sample Type	Analyte	Average Concentration of all Participants (pCi/L)	2 SD of all Participants (pCi/L)	ISU Measured Concentration (pCi/L)	3 SD of ISU Measured Concentration (pCi/L)	Within Criteria?[1]
12/15/99	Soil	^{60}Co	1.8	0.9	1.8	0.1	Yes
		^{134}Cs	0.0	0.3			NA
		^{137}Cs	43.8	13.7	44.5	1.2	Yes
		^{152}Eu	51.5	30.5	44.6	5.5	Yes
		^{154}Eu	5.4	2.3	5.0	0.4	Yes
		^{155}Eu	1.0	1.9			NA
		^{40}K	12.6	6.2	11.3	4.1	Yes
		^{236}U	15.2	5.0	14.3	2.9	Yes

[1] ISU EML criteria for spiked samples was used, since the acceptable range was not established by QATF.

Table 8-6. Electret Ionization chamber results from 12th annual international intercomparison of environmental dosimeters sponsored by the Department of Energy EML

Test Conditions	"Known Value" (µGray)	INEEL OP Net Absorbed Dose (µGray)	Relative Difference
Lab Cs-137	391 ± 11[a]	381.2 ± 10[a]	-2.5%
Field Only	161 ± 10	114.3 ± 8	-29.0%
Field + Cs-137 (beginning)	548 ± 16	553.2 ± 11	1.0%
Field + Cs-137 (middle)	391 ± 11	507.6 ± 11	29.8%
Field + Cs-137 (end)	623 ± 18	645.9 ± 9	3.7%

[a] Corresponds to a 1-sigma measurement uncertainty or tolerance.

Spiked samples for laboratory comparison purposes in cooperation with the USGS and BBWI

The USGS and INEEL OP cooperatively prepared spiked samples using a NIST-traceable standard obtained by the USGS from DOE Environmental Measurements Laboratory. The standard was mixed with deionized water to produce samples that were submitted blind by the USGS, by BBWI, and by the INEEL OP to their respective analysis laboratories. Samples were prepared at approximately the contract MDC and at 3-4 times the MDC for each of the analyzing laboratories. Results for all INEEL OP samples compared to the reference values were within three times the pooled sample error, and had acceptable relative percent differences. USGS is currently completing a thorough review of all spiked sample results as a basis for an inter-laboratory comparison tailored to the needs of those conducting environmental monitoring at the INEEL. Although laboratory *a-priori* MDC values differed for the laboratories, one set of samples at the same concentration was sent to all laboratories. When compared, sample results from all laboratories were in agreement, **Table 8-7**.

Table 8-7. INEEL OP analysis results for spiked samples prepared with USGS compared with reference values

Sample Number	Sample Date 2001	Plutonium-238						
		Result	± 3 SD	MDC	Ref. Value	± 1 SD	ESP with Reference	RPD
014W206	10/12	0.02	0.12	0.033	0.20	0.01	<3 SD	-0.1
014W208	10/12	0.68	0.24	0.14	0.66	0.05	<3 SD	-3.4
014W209	10/12	0.013	0.049	0.11	0.00	0.00	<3 SD	
Reanalysis								
014W206	10/12	0.152	0.049	0.037	0.20	0.01	<3 SD	27.2
014W208	10/12	0.58	0.14	0.046	0.66	0.05	<3 SD	12.5

Table 8-7 continued. INEEL OP analysis results for spiked samples prepared with USGS compared with reference values

Sample Number	Sample Date 2001	Plutonium-239/240						
		Result	± 3 SD	MDC	Ref. Value	± 1 SD	ESP with Reference	RPD
014W206	10/12	0.16	0.11	0.08	0.21	0.02	<3 SD	28.6
014W208	10/12	0.65	0.23	0.092	0.70	0.05	<3 SD	7.6
014W209	10/12	0.016	0.032	0.029	0.00	0.00	<3 SD	
Reanalysis								
014W206	10/12	0.152	0.046	0.0091	0.21	0.02	<3 SD	33.6
014W208	10/12	0.58	0.14	0.046	0.66	0.05	<3 SD	

Table 8-7 continued. INEEL OP analysis results for spiked samples prepared with USGS compared with reference values

Sample Number	Sample Date 2001	Americium-241						
		Result	± 3 SD	MDC	Ref. Value	± 1 SD	ESP with Reference	RPD
014W206	10/12	0.26	0.13	0.094	0.22	0.02	<3 SD	-17.1
Reanalysis								
014W206	10/12	0.244	0.06	0.0088	0.22	0.05	<3 SD	-10.7

Corrective Actions

There were a few issues that resulted in the need to implement corrective actions by either the analysis laboratory or INEEL OP.

For two of the sampling quarters of 2001, ISU-EML reported suspected laboratory contamination with tritium and cesium-137. Several results from Magic Valley samples were above the MDC using the standard tritium method. Since there is no history of tritium above the MDC in Magic Valley water samples using the standard method, and because laboratory tritium contamination was suspected, aliquots of all of the Magic Valley tritium samples were re-distilled and recounted. None of the re-distilled and recounted aliquot results were above the MDC, suggesting that the samples had become contaminated. This, as well as past tritium problems in the laboratory, indicated that laboratory contamination is the most probable cause. While a specific event or timeframe could not be identified, all samples were qualified as estimate values due to this unquantified uncertainty. Specific analysis results where tritium was detected in the initial analysis but not in the redistilled analysis were rejected and not included in the averaged final result.

Corrective actions included ISU moving its tritium sample preparation to another building, where tritium contamination does not appear to be a problem.

ISU-EML rejected three gamma analyses results for quarterly PM_{10} composite samples. The analyses results were rejected due to cesium-137 contamination on one instrument. The instrument was decontaminated and all three samples were recounted. Recount results were all less than MDC for cesium-137. The cesium-137 contamination was less serious than the tritium contamination because the samples were not contaminated and were successfully re-analyzed after the instrument was decontaminated.

The contract laboratory did not meet their internal quality assurance requirements for a plutonium-241 analysis. The contract laboratory stated that these results should not be considered to be accurately quantitative or compliant with published methodologies. Unfortunately, there was not sufficient sample volume remaining for a re-analysis. The INEEL OP reported the data, however; the analysis result was flagged as rejected. The laboratory errors that led to the inaccurate data have been corrected. As a further measure, future samples submitted for plutonium-241 analyses will be sent in a separate one-liter container so that there will be sufficient sample for multiple re-analyses should that become necessary.

Chapter 9
Conclusions and Plans for Future Work

Conclusions

Having completed an independent assessment of the environmental conditions at the INEEL to provide verification of DOE monitoring results for 2001, the INEEL OP concludes:

- While no contamination attributable to the INEEL was identified in samples collected at distant or Magic Valley monitoring sites, INEEL impacts can be identified at some sites along the southern boundary of the INEEL.

- Measurable onsite environmental impacts from the INEEL were observed.

- Results from contaminants in groundwater and soil from past releases, and airborne tritium from 2001 emissions, remained well below regulatory limits, with the exception of some onsite groundwater results measuring above drinking water standards. Notably, none of these wells was used for consumption of water by humans.

- Comparisons of results between the INEEL OP and DOE contractors agreed well in most areas. In particular, some of the correlations between INEEL OP and USGS water quality results were excellent. Agreement between *in-situ* gamma measurements was also excellent.

Appendix A
The Design and Development of the INEEL Oversight Program's Environmental Surveillance Program

History and Legislative Authority

In the late 1980s, at a time when facts about contamination from a half century of defense-related production were gradually coming to light, and DOE's credibility with state governments was consequently deteriorating, the U.S. Secretary of Energy proposed the concept of oversight roles for states hosting DOE facilities. Under this new proposal, the states would be given access to DOE facilities and information so that each state could conduct independent assessments of the potential environmental impacts resulting from DOE activities. The details of such arrangements were to be negotiated in agreements-in-principle (AIP), wherein DOE would obligate funds to ensure that states could carry out their oversight responsibilities.

On April 5, 1989, the Idaho Legislature enacted Senate Bill 1266, establishing a comprehensive oversight program for the INEEL, and on May 1, 1990, the state of Idaho and the DOE signed a five-year AIP entitled the Environmental Oversight and Monitoring Agreement (State of Idaho-DOE 1990). This agreement provided grant funding and other resources for establishing and supporting the state's INEEL OP, which was assigned the following responsibilities:

- Secure necessary data and information regarding DOE activities in Idaho;
- Scientifically evaluate this information in the context of total INEEL impacts on the public and environment; and
- Objectively report conclusions to the people of Idaho.

When the first AIP grant expired in 1995, the state of Idaho, DOE, and NRF negotiated a subsequent five-year AIP, which reinforced the fundamental elements of the program and built on the experience gained during the first five years of INEEL OP operations. INEEL OP, the DOE and NRF negotiated another subsequent five-year AIP in 2000.

By working cooperatively with DOE, INEEL OP has developed a successful program that includes a strategic monitoring network designed to supplement and verify DOE's environmental monitoring data, which allows the state of Idaho to provide independent oversight and surveillance of the environment and DOE activities at the INEEL.

Environmental Surveillance Program Network Design

The INEEL OP surveillance network selectively and independently collects samples of environmental media that could be contaminated by activities at the INEEL. Media sampled include air, surface water, groundwater, soil, and milk. The evolution of the INEEL OP monitoring network is summarized below.

Air Monitoring

The INEEL OP air monitoring network was created through a research and development agreement with DOE to conduct independent air monitoring activities on and around the INEEL.

By evaluating meteorological records, results from dispersion models, and the locations of actual or potential air emission sources at INEEL, the program identified potential offsite locations for six permanent air quality monitoring stations. Four of these sites were situated around the perimeter of the INEEL at Mud Lake, Monteview, Howe, and Atomic City. A fifth site was established on the INEEL at the Big Lost River Rest Area on U.S. Highway 20/26. Initially, these five sites were equipped with low-volume particulate samplers loaned to the INEEL OP by the U.S. Environmental Protection Agency (EPA). In 1992, these samplers were replaced with similar samplers, acquired from DOE's contractor surplus, which INEEL OP operated according to QA/QC and standard operating procedures. The sixth site, in Idaho Falls, was added to the network in the fall of 1992 to serve as a distant background monitoring location. Collectively, these six stations now serve as permanent monitoring stations in the air surveillance program.

In January of 1994, following DOE's decision to privatize its environmental surveillance program, the INEEL OP incorporated the four ISU Environmental Monitoring Program air-monitoring stations into its network. These stations, previously operated by ISU for DOE, included three locations on the INEEL--Sand Dunes Tower, Experimental Field Station, and Van Buren Avenue, and one offsite location at the Craters of the Moon National Monument. **Figure 2-1** in **Chapter 2** of this report provides the locations of these sites.

Currently, the network instrumentation of the ten air monitoring stations includes samplers to collect airborne particulate matter smaller than ten micrometers in diameter (PM_{10}), atmospheric moisture, and gaseous radioiodine. Precipitation samplers operate at six of the ten monitoring

stations to collect samples for radiological analyses. In mid-January of 2001, the INEEL OP began investigating high-volume total suspended particulate air samplers as a replacement for aging PM_{10} samplers. Ten TSP samplers were deployed at the ten air monitoring stations and data collected form these samplers will be compared with the data collected from the PM_{10} samplers.

External Radiation Monitoring

Each of the ten air monitoring stations described above is further equipped with an environmental dosimeter to measure time-integrated exposure to gamma radiation. For real-time measurement of ambient gamma radiation, the six original stations also employ high-pressurized ion chambers, from which data can be relayed via radio transmitter to the INEEL OP Idaho Falls office.

Expanding the radiation monitoring network in 1995, the INEEL OP applied historical meteorological data and dispersion modeling information to the process of selecting strategic locations for additional radiation monitoring stations. Now in place at Rover, the Base of Howe Peak, the Main Gate, and near Big Southern Butte, these stations include both environmental dosimeters and high-pressurized ion chambers, and, with the exception of the Main Gate location, are powered by solar energy. The locations of these sites are shown on **Figure 2-2** in Chapter **2** of this report.

In 1999, the INEEL OP implemented a new type of environmental dosimeter to replace the thermoluminescent dosimeters previously used. Electret ion chambers (EIC) were deployed at the six original stations, the four stations formerly operated by ISU, and Rover, the Base of Howe Peak, the Main Gate, and near Big Southern Butte. In addition, EICs are deployed around the perimeter of the INEEL approximately every two miles and at NOAA mesonet towers throughout southeastern Idaho for a total of 82 locations. The locations of these sites are shown on **Figure 2-2** in **Chapter 2** of this report.

Terrestrial Media Monitoring

Deposition of radioactive material released from INEEL facilities to the air can cause accumulation and migration of radionuclides in the environment that may lead to human exposure or adverse environmental impacts. Terrestrial media that can be sampled to assess potential human and environmental exposure to deposited radioactive material includes but is not limited to soil, vegetation, and milk.

The methodology used by the INEEL OP to identify terrestrial monitoring locations included an assessment of potential INEEL facility air emission characteristics, the evaluation of monitoring activities by other agencies, and careful consideration of INEEL OP objectives. Initially, soil monitoring locations were selected to further characterize the environment around the permanent air monitoring stations. Co-locating these two sampling activities supported comparisons of related background and long-term data trends. Periodically, an *in-situ* gamma spectrometer

could be employed to determine background radiation information at co-located sampling locations.

Water Monitoring

Contamination of the Snake River Plain Aquifer underlying the INEEL is generally limited to areas near TAN, INTEC, TRA, CFA, and RWMC as shown in **Figure A-1**. In these areas, the concentration of one or more contaminants in the aquifer approaches or exceeds federal drinking water standards. Because the USGS has been monitoring water quality at the INEEL since 1949, many of the more than 300 wells presently used to monitor the Snake River Plain Aquifer in the vicinity of the INEEL are observation wells originally installed by the USGS.

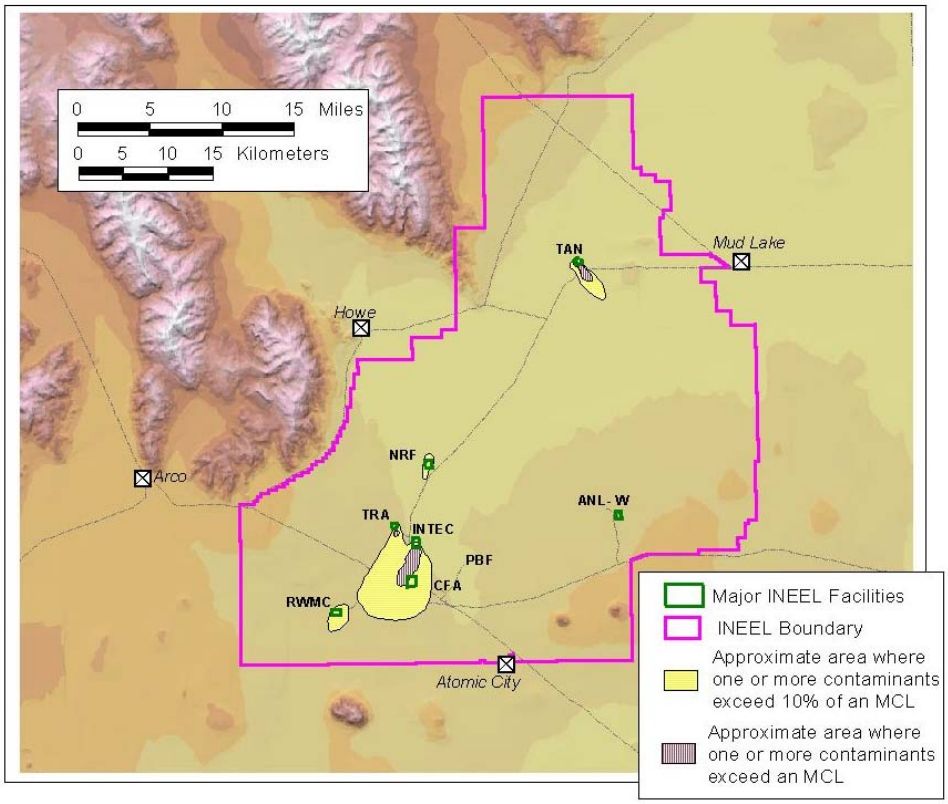

Figure A-1. Plume map showing areas of contamination of the Snake River Plain Aquifer at the INEEL

The INEEL OP water surveillance network combined two previously existing surveillance programs in 1993. The first, established by the ISU Environmental Monitoring Program in 1989, had previously conducted replicate sampling with DOE contractors and the USGS INEEL Project Office at 23 locations on and off the INEEL. The second, a cooperative program between the USGS and the Idaho Department of Water Resources (IDWR), performed sampling to determine the quality of water in the Snake River Plain Aquifer between the southern boundary

of the INEEL and the Thousand Springs area along the Snake River near Hagerman. Merging these two surveillance programs, the INEEL OP assumed monitoring responsibilities from the ISU Environmental Monitoring Program, funded a position in IDWR to cover the expenses of collecting samples south of the INEEL, and implemented a three-year rotation sampling schedule for 55 sites. In addition, the INEEL OP water surveillance program initiated a new sampling program in 1999 to co-sample wastewater and groundwater collected by BBWI, ANL-W and NRF on the INEEL.

Over the past five years, the INEEL OP has expanded the number of monitoring locations originated by the surveillance programs and will continue to selectively add wells or springs to the network when one or more of the following criteria are met:

- Water from the location is used by the public;
- The location provides long-term community monitoring trends;
- Sampling from the location verifies and supplements monitoring by the INEEL contractor; and/or
- The location provides information at critical points along the groundwater pathway.

Currently, the INEEL OP collects water samples from 76 wells, 8 springs, and 3 surface water locations on and off the INEEL. With regard to the new wastewater and groundwater sampling in 2001, 11 wastewater sites and 18 groundwater sites were sampled. Additional information regarding the locations, sampling schedules, and co-sampling organizations associated with the water monitoring program is provided in **Chapter 2** of this report.

Appendix B: Glossary, Acronyms and Units

Glossary

A priori—Prior to measurement.

Accuracy—The degree of agreement of a measured value with the --true-- or expected value.

Activation products—Isotopes produced from the absorption by nuclei of neutrons in a nuclear reactor.

Activity—See radioactivity.

Alpha particle—Particle that is emitted from the nucleus of an atom, and contains two protons and two neutrons. Identical to the nucleus of a helium atom, without the electrons, an alpha particle is a form of radiation that can travel only a few millimeters in air, and be stopped by a piece of paper. Uranium-238, radium-226, and polonium-210 are all alpha emitters.

Atom—The smallest particle of an element that retains all the chemical and physical characteristics of that element. Every known atom consists of negatively charged electrons traveling around a nucleus. The nucleus, or core, of an atom contains protons, which are positively charged, and neutrons, which are uncharged.

Atomic weight—A number that identifies a specific isotope numerically equal to the number of protons and neutrons in the isotope. For example, the "90" in strontium-90 indicates a total of 90 protons and neutrons in the nucleus.

Background—Naturally occurring or constantly present radioactivity or chemical species in an environment. Cosmic rays and terrestrial radiation are two contributors to natural background.

Beta particle—A high-speed particle, identical to an electron, that is emitted from the nucleus of an atom. Beta radiation can be stopped by a thin sheet of metal about the thickness of foil. Strontium-90, cesium-137, and tritium are beta emitters.

Committed effective dose equivalent—The dose equivalent that will accumulate during the 50 years following the intake of a radionuclide.

Confidence interval—The range of values that may be expected to encompass the true value.

Cosmic radiation—Radiation which permeates all of space, from sources primarily outside our solar system. The radiation is in many forms, from high-speed, heavy particles to high-energy photons. Examples of cosmogenic radionuclides are carbon-14, tritium, and beryllium-7.

Cosmogenic radioactivity—Unstable atoms resulting from the interaction between cosmic radiation and atoms in the atmosphere. Examples of cosmogenic radionuclides include carbon-14, tritium, and beryllium.

Decay—The spontaneous transformation of one nuclide into a different nuclide or a different energy state of the same nuclide. For a radioactive nuclide, this transformation process results in the emission of nuclear radiation, such as alpha, beta, or gamma radiation.

Decay chain—The series of different nuclides into which a nuclide will change until a stable nuclide has been formed. During decay, nuclides may transform many times.

Disintegration—See decay.

Dose—A measurement of the quantity of energy absorbed per unit mass from any kind of ionizing radiation, also called absorbed dose. The traditional unit of absorbed dose is the rad.

Duplicate sample—A second sample randomly selected from a population of interest to assist in the evaluation of sample variation.

Effective dose equivalent—The summation of the weighting factor for tissue multiplied by the dose equivalent to tissue.

Electret ion chamber—An ionization chamber made up of polypropylene plastic which provides a nearly air-equivalent chamber. EICs are used to measure cumulative total of environmental gamma radiation exposure.

Exposure—A measure of ionization produced in air by x-rays or gamma rays. Unlike dose, exposure refers to the potential of receiving radiation. The traditional unit is the roentgen.

Fission—The splitting of nuclei by neutrons.

Gamma rays—Electromagnetic waves or photons emitted from the nucleus of an atom. Gamma radiation is very penetrating and is best attenuated by dense materials such as lead. Technetium-99m is used for medical imaging. Technetium-99m is a soft beta emitter.

Gamma spectroscopy—Technique used to determine the distribution of radionuclides in a sample. Gamma spectroscopy identifies radionuclides since the gamma ray spectrum is characteristic for the radionuclides present in the sample.

Gas-flow proportional counting—Technique used to make gross alpha and gross beta screening measurements in a sample. Uses a gas-filled detector under certain conditions. Under these conditions, the number of counts in the detector is proportional to the number of ionization events taking place.

Gross alpha—Total alpha activity detected. Assumes all activity due to a single radionuclide with no species identified or decay corrected.

Gross beta—Total beta activity detected. Assumes all activity due to a single radionuclide with no species identified or decay corrected.

Half-life—The time it takes for one half of the atoms of a particular radionuclide to decay into another nuclear form. Measured half-lives vary from less than millionths of a second to billions of years.

Health physics—The interdisciplinary science and application of science for the radiation protection of humans and the environment. Health physics combines the elements of physics, biology, chemistry, statistics and electronic instrumentation to provide information that can be used to protect individuals from the effects of radiation.

High-pressure ionization chamber—A pressurized ion chamber is a sensitive photon detector capable of real-time measurements and provides real-time environmental gamma radiation exposure measurements.

In situ gamma spectroscopy—Gamma spectroscopic measurements performed *in situ*. The detector is placed directly over the area being analyzed. The advantage to this technique is that samples are not taken, which, in turn, minimizes the potential for cross-contamination and waste production.

Injection well—A well used for the disposal of wastewater.

Ionization—The process of adding one or more electrons to, or removing one or more electrons from, atoms or molecules, thereby creating ions (charged particles). High temperature, electrical discharge, nuclear radiation, and x-rays can cause ionization.

Ionizing radiation—Radiation with enough energy to remove tightly bound electrons from their orbits during an interaction with an atom, causing the atom to become charged or ionized.

Isotope—One of two or more atoms that have the same number of protons but a different number of neutrons in their nuclei. The atoms have nearly the same chemical properties, but their physical properties often differ. A radioactive isotope is called a radioisotope.

Liquid scintillation counting—A counting technique used to measure low-energy beta particles or alpha particles that involves the dissolution of the sample to be counted directly into a liquid scintillator.

Low-level radioactive waste—Waste that does not generally require shielding or heat removal, usually possessing small transuranic content.

Mean—Arithmetical average of a set of numbers.

Minimum detectable activity (MDA)—An *a priori* estimate of the activity that can be identified in a sample with 95% confidence under specified measurement conditions.

Minimum detectable contamination (MDC)—An *a priori* estimate of the activity concentration that can be identified with 95% confidence under a specified set of measurement conditions.

Non-ionizing radiation—Radiation lacking the energy to remove tightly bound electrons from their orbits around atoms. Examples are microwaves and visible light.

Nuclides—A general term used to denote the core, or nucleus, of all known atoms, both stable and unstable.

Neutrons—Neutral particles that are normally contained in the nucleus of all atoms, but may be removed by various interactions or processes like collision and fission.

Perched ground water –A layer of water-saturated sediment or rock separated from the underlying aquifer by unsaturated sediment or rock.

Perched water table—The upper surface of a body of perched water.

Percolation pond—Unlined wastewater pond where some of the water infiltrates into the ground.

pH—A measure of the acidity or alkalinity of a chemical solution; the negative log of the hydrogen ion concentration of a solution.

PM_{10}—All particulate matter in the ambient air with an aerodynamic diameter less than or equal to 10 micrometers. This size fraction is presumed to be respirable and is, therefore, of special interest.

Precision—A qualitative term used to describe the amount of random error in the measurement process, precision is a measure of the degree to which data generated from repeated measurements differ from one another.

Quality assurance—A management function that deals with setting policy and running an administrative system of management controls that cover planning, implementation, and review of data collection activities.

Quality control—Typically, all the scientific precautions, such as calibrations of equipment and duplicate sampling, that are needed to acquire data of known and adequate quality. Quality control is technical in nature and is implemented at the project level.

Radiation—Energy in transit in the form of high-speed particles and electromagnetic waves.

Radiation dose—The amount of energy deposited in biological tissues per weight of tissue.

Radioactive contamination—Radioactive material in an unwanted place.

Radioactive material—Any material that contains radioactive atoms.

Radioactivity—The spontaneous transformation of an unstable atom, which often results in the emission of radiation. This process is referred to as a transformation, a decay, or a disintegration of an atom.

Radioisotope—An unstable isotope or element that decays or disintegrates spontaneously, emitting radiation.

Radionuclide—A radioactive nuclide.

Sample variance—A measure of the dispersion of varieties observed in a sample expressed as a function of the squared deviations from the sample average.

Secondary maximum contaminant level—National drinking water standards regulating contaminants that primarily affect the aesthetic qualities of drinking water. At considerably higher concentrations, these contaminants may become health concerns.

Sigma (standard deviation)—A measure of the variability of a set of values; the square root of the variance.

Spent nuclear fuel—Nuclear fuel that has been removed from a reactor after use to produce power.

Split sample—The type of replicate sample produced when a laboratory divides one sample into subsamples.

Thermoluminescent dosimeter—A monitoring device that can be worn by an individual or placed in the environment to measure total gamma radiation during a period of time.

Transuranic waste—Waste that contains isotopes above uranium in the periodic table of chemical elements in levels exceeding 100 nanocuries per gram. Typically, transuranic waste contains by-products of fuel assembly, weapons fabrication, and/or reprocessing operations.

Tritium (H-3)—A radioactive isotope of hydrogen that has two neutrons and one proton in the nucleus.

X rays—Electromagnetic waves or photons not emitted from the nucleus, but normally emitted by energy changes in electrons. These energy changes occur either in electron orbital shells that surround an atom or during the process of slowing energy down, such as in an x-ray machine.

Acronyms

AIP—Agreement-in-principle

ANL-W—Argonne National Laboratory- West

BBWI—Bechtel BWXT Idaho, LLC

CERCLA—Comprehensive Environmental Response, Compensation, and Liability Act, also known as Superfund

CFA—Central Facilities Area

DOE—U.S. Department of Energy

DQO—Data Quality Objective

EIC—Electret ion chamber

EPA—U.S. Environmental Protection Agency

ESER—S. M. Stoller Corporation, Environmental Surveillance Education Research

ESP—Environmental Surveillance Program

HPIC—High-pressure ionization chamber

IBL—State of Idaho Department of Health and Welfare Bureau of Laboratories

ICP—Inductively Coupled Plasma Emission Spectroscopy

INTEC—Idaho Nuclear Technology and Engineering Center (renamed in 1998 from Idaho Chemical Processing Plant).

INEEL—Idaho National Engineering and Environmental Laboratory

INEEL OP—Idaho National Engineering and Environmental Laboratory Oversight Program

ISU EML—Idaho State University Environmental Monitoring Laboratory

LMITCO—Lockheed Martin Idaho Technologies Company

MAPEP—Mixed Analyte Performance Evaluation Program

MCL—maximum contaminant level

MDA—minimum detectable activity

MDC—minimum detectable concentration

NIST—National Institute of Standards and Technology

QATF—Environmental Radiation Quality Assurance Task Force of the Pacific Northwest

NOAA—National Oceanic and Atmospheric Administration

NRF—Naval Reactors Facility

PBF—Power Burst Facility

QA—Quality Assurance

RCRA—Resource Conservation and Recovery Act

ROD—Record of Decision

RWMC—Radioactive Waste Management Complex

SB—Shoshone-Bannock Tribes

SMCL—secondary maximum contaminant level

TAN—Test Area North

TLD—Thermoluminescent Dosimeter

TRA—Test Reactor Area

USGS—U.S. Geological Survey

VOC—Volatile Organic Compounds

WLAP—Wastewater Land Application Permit

Units

Curie (Ci)—A unit used to measure radioactivity. One curie equals that quantity of a radioactive material that will have 37,000,000,000 transformations in one second. Often radioactivity is expressed in smaller units: thousandths (mCi), millionths (uCi), billionths (nCi), or trillionths (pCi) of a curie. The International Standard (SI) unit that is comparative to the curie is the becquerel (Bq). There are 3.7E10 Bq in one curie.

Rad—Acronym for radiation absorbed dose. The rad is a unit used to measure a quantity called absorbed dose. This relates to the amount of energy actually absorbed by some material, and is used for any type of radiation and any material. One rad is defined as the absorption of 100 ergs per gram of material. The unit rad can be used for any type of radiation, but it does not describe the biological effects from different radiations. The International Standard (SI) unit that is comparative to the rad is the gray (Gy). There are 100 rads in one gray.

Rem—Acronym for roentgen equivalent in man. The rem is a unit used to derive a quantity called equivalent dose. This relates the absorbed dose in human tissue to the effective biological damage of the radiation. Not all radiation has the same biological effect, even for the same amount of absorbed dose. Equivalent dose is often expressed in terms of thousandths of a rem, or mrem. To determine equivalent dose (rem), the absorbed dose (rad) is multiplied by a quality factor (Q) that is unique to the type of incident radiation. The International Standard (SI) unit that is comparative to the rem is the sievert (Sv). There are 100 rem in one sievert.

Roentgen (R)—The roentgen is a unit used to measure a quantity called exposure, but only when used to describe an amount of gamma and X-rays in air. One roentgen is equal to depositing to 2.58E-4 coulombs of energy per kg of dry air, and is a measure of the ionizations of the molecules in a mass of air. The main advantage of this unit is that it is easy to measure directly, but it is limited because it is only for deposition in air, and only for gamma and x-rays.

SI Prefixes—Many units are broken down into smaller units or expressed as multiples using standard metric prefixes. As examples, a kilobecquerel (kBq) is 1000 becquerels, a millirad (mrad) is a thousandth of a rad, a microrem (urem) is a millionth of a rem, a nanogram (ng) is a billionth of a gram, and a picocurie (pCi) is a trillionth of a curie.